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## *FINAL REPORT*

**19990291**

**OPTIMIZING INOCULATION AND FERTILIZATION FOR CHICKPEA AND LENTIL (ON CLAY SOILS)**

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# *Optimizing Inoculation and Fertilization for Chickpea and Lentil*

**(Final Report)**

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Saskatchewan Pulse Growers

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# OPTIMIZING INOCULATION AND FERTILIZATION FOR CHICKPEA AND LENTIL IN THE SEMIARID CANADIAN PRAIRIE

## ABSTRACT

Canada is a leading exporter of lentil and chickpea. These two drought-tolerant pulse crops have been integrated into farming systems in the semiarid regions of western Canada as a means of diversifying crop production and improving whole-farm economics. However, little information is available regarding rhizobium inoculation and fertilization requirements of these pulses. A field study was conducted on a medium-textured loam soil at Swift Current in 1999, 2000, and 2001, and on a heavy clay soil at Stewart Valley in 2000, 2001, and 2002. The objectives of the research were to (i) determine the effects of rhizobium inoculation and fertilization on nodule formation, $N_2$-fixation, and their impacts on growth, yield, and seed quality in chickpea and lentil, and (ii) develop recommendations for optimizing rhizobium inoculation, P-solublizing inoculant, and fertilizer N and P application for direct-seeding of chickpea and lentil with seeder having 1-, 2-, and 3-tank delivery systems. The results of the six site-years showed that use of rhizobium inoculation increased an average seed yield by 35% for desi, 7% for kabuli, and 23% for lentil. Inoculation reduced desi plant population by 10%, but not in kabuli or lentil. Granular inoculant increased yield by 7% in chickpea and 8% in lentil, compared to peat-based powder inoculant. Placement of granular inoculant (seed-row vs side-banding) had no effect in any of the pulses. Starter -N and P at a rate of 15 kg $ha^{-1}$ each had a marginal effect on plant growth and seed yield, but a higher rate of P (34 kg $P_2O_5$ $ha^{-1}$) increased kabuli seed size. Chickpea and lentil did not show any response to *Penicillium bilaii* (fungus contained in products JumpStart and TagTeam) under the semiarid growing conditions. This study has produced a large volume of data; some of the research findings would make significant contributions to global sciences. The timely information generated from this study will provide Canadian pulse growers with new and updated information in the area of optimizing inoculation and fertilization, maximizing seed yields and quality, and enhancing the economic returns of their investment in the production of chickpea and lentil. The outcome of this research will have a significant impact on Canadian pulse industry.

## EXECUTIVE SUMMARY

**Site-years.** This study was conducted from 1999 to 2002 at two sites in southwestern Saskatchewan. The first site was at Swift Current on an Orthic Brown Chernozem with silt loam texture and a saturated-paste pH of 6.5 in the 0-15 cm depth. The second site was at Stewart Valley on a Rego Brown Chernozem with heavy clay texture and a saturated-paste pH of 6.8 in the 0-15 cm depth.

**Research Funding.** This project was funded by Saskatchewan Pulse Growers (SPG), Saskatchewan Agricultural Development Fund (ADF) of Saskatchewan Agriculture, Food, and Rural Revitalization (SAFRR), Potash and Phosphate Institute of Canada (PPIC), and Matching Investment Initiatives of Agriculture and Agri-Food Canada (MII).

**Rhizobium Inoculantion**. There was a tendency for rhizobium inoculation to reduce plant population significantly in 5 of the 6 site-years for desi-chickpea, but this trend was not evident for kabuli or lentil. Plants inoculated with rhizobium increased seed yield by an average of 35% in desi chickpea, and 23% in lentil, when compared to the non-inoculated crops. Kabuli chickpea expressed less drastic responses to inoculation, with a 7% increase in seed yield across the six site-years. Kabuli chickpea has stronger ability to fix N or a stronger rooting system to uptake the needed N from deep soil layers even if a rhizobium source is not provided.

***Peat-based Powder versus Granular Inoculant***s. Granular inoculant increased seed yield by an average 7% in chickpea and 8% in lentil, compared to peat-based powder inoculant. However, lentil showed a wide range of response to inoculant formulation with granular increasing seed yield from 3 to 38%, except for one site-year (2000 SC) where yield was lower with granular inoculant. Use of granular in both chickpea and lentil is strongly encouraged. The extra cost associated with the use of a granular inoculant product is less than the extra net income earned due to increased seed yield from granular inoculation.

***Placement of Granular Inoculant.*** Granular inoculant placed in the seed-row was compared with a side-banded placement. The results showed that the placement of rhizobium inoculant did not affect plant establishment for any of the three pulses. Seed yield or seed weight was not related to the inoculant placement in general. No differences were found between the two application methods for kabuli chickpea or for lentil, although in 4 of the 6 site-years the seed yield of desi chickpea was slightly (2%) higher for seed-row application compared to side-band treatments.

***Starter N.*** Starter N at the rate of 15 kg N $ha^{-1}$ did not affect plant establishment for chickpea or lentil. The N application reduced slightly plant population for lentil (3% drop), but it was not statistically significant. Starter N increased seed yields by an average of 2% for desi chickpea, 5% for kabuli chickpea, and 4% for lentil.

Although the increases in seed yield were found in 5 of 6 site-years, they were only statistically significant for kabuli chickpea. Given the fact that kabuli chickpea responded to rhizobial inoculation less than desi chickpea (as described earlier) and kabuli responded better to N fertilizer than desi, the results strongly suggested that further study of the interaction between fertilizer N and inoculation is required to produce sound recommendations.

The application of Starter N improved harvestability by increasing plant height and the lowest pod height in all pulses studied. This improvement was due to applied N boosting vegetative growth in early growth stages. Plots that received Starter N were greener, more vigorous before flowering than plots that did not receive N. Starter N at the rate of 15 kg N $ha^{-1}$ accelerated plant maturity by a merely 0.5 to 0.7 days, which is marginal, despite being statistically significant.

***Phosphorous Effect***. Phosphorous applied at a rate of 15 kg $P_2O_5$ $ha^{-1}$, compared to the non-P check treatment, did not affect any of the growth- or yield-related variables measured in this study. No P response was found, except for lentil that P increased seed yield in 4 of 6 site-years by an average of 4%. Application of P increased the lowest pod height of kabuli chickpea by an average of 11 mm, suggesting an improvement in harvestability of 5%.

Phosphorous at a rate of 34 kg $P_2O_5$ $ha^{-1}$, compared to 0 and 17 kg $P_2O_5$ $ha^{-1}$, increased the proportion of the ≥9-mm diameter seeds (54% vs 59%), implying an increase of the price premiums from the large-sized seed. Such a P response was not observed when the kabuli was seeded in early-May. The earlier-seeded chickpea had a longer period of time to develop stronger rooting systems that may help to uptake nutrients from deeper soil layers, thus no effect of fertilizer P application on kabuli seed size was detected.

***Penicillium bilaii.*** The soil-isolated fungus *Penicillium bilaii* did not affect plant establishment or seed yield for any of the three pulse crops tested. JumpStart did not result in any improvement in harvestability (such as plant height, lowest pod height, maturity) of the pulses. In 17 of the 18 crop site-years (with one exception), the plots that received *Penicillium bilaii*, compared to plots received no *Penicillium bilaii*, produced identical seed yields for all three pulses studied. Similarly, plots that received TagTeam (which contains *Penicillium bilaii* and rhizobium) produced identical plant establishment and seed yields as the plots that received rhizobium inoculant without *Penicillium bilaii*.

## TECHNICAL REPORT

### 1. Background

Canada is the world's largest exporter of lentils and the major chickpea supplier. These two drought-tolerant pulse crops have been integrated into the farming systems in the semiarid regions of western Canada as a means of diversifying crop production and improving whole-farm economics. However, the area seeded to chickpea in western Canada was dropped significantly in the last two years (2001, 2002) partly due to lack of knowledge and management recommendations. In order to expand our knowledge with these new crops, a project was initiated at two locations in the semiarid regions of Saskatchewan, evaluating the crop management strategies for optimizing rhizobium inoculation and fertilization.

For example, many producers want to use granular inoculants on pulse crops, but in air seeder with a 2-tank delivery system, the use of granular inoculant precludes application of fertilizer P (pulses require sufficient P supply to maximize $N_2$ fixation). Use of P-solublizing seed inoculant such as JumpStart (*Penicillium bilaii*) in one tank and granular rhizobial inoculant in another tank is one option; such an option may be beneficial when soil residual phosphate level is low and when the crop is to be grown on land that had not been grown pulses before. Another option is to pre-inoculate the seed with peat-based powder and the second tank for granular P-fertilizer. In a 3-tank seeding systems there are more options to accommodate the multiple requirements, but no information is available regarding the relative performance of side-banding vs seed-row placement of granular inoculant.

### 2. Objectives

The objectives were:

( i) to determine the effects of rhizobium inoculation and fertilization on nodule formation, $N_2$-fixation, plant growth, seed yield, and market quality of chickpea and lentil grown in the semiarid prairies, and

( ii) to develop recommendations for pulse growers in optimizing inoculation with rhizobium and P-solublizing inoculants, and use of N and P fertilizers for no-till seeded kabuli- and desi-chickpea and lentil, using 1-, 2-, and 3-tank seeding systems.

**3. Seeding and Crop Management**

Kabuli-chickpea (Sanford in 1999, CDC Xena in 2000 and 2001), desi-chickpea (Myles in all years), and lentil (Laird in 1999 and CDC Glamis in 2000 and 2001) were seeded at the two experimental sites; one on a silt loam soil at Swift Current, and the other on a heavy clay soil at Stewart Valley, both in Saskatchewan. The fields used in this study had no pulse crops grown in the past five years. Prior to seeding in each year, the residual soil N was measured to a soil depth of 120-cm in several fields to select a suitable site with low to medium residual soil N. The residual soil N ranged from 10 to 20 kg N $ha^{-1}$ (except 2002 Swift Current) and residual soil P ranged from 10 to 28 kg $P_2O_5$ $ha^{-1}$ (Table 1). These conditions of the land allow us to determine the true effect of fertilizer and rhizobium inoculants that we use in the trials. Plots were seeded directly into wheat stubble using a hoe press seeder that is equipped with three separate tanks. Both rhizobium granular soil inoculant and seed-applied peat-based powder inoculant were used at the recommended rates. The two forms of inoculants contain identical *Bradyrhizobium* strains, allowing us to make true comparisons between the two forms of inoculants. The experiment was set up as a randomized complete block design with 4 replicates at each site. To avoid potential cross-contamination from rhizobium inoculants among treatments, the seed compartments were cleaned between treatments using a high pressure air flow before running some sand through the hoses and the openers. Other detailed agronomic information regarding the cultivars, seeding dates and soil temperatures at seeding, harvest dates, and the soil available nutrients (N-P-K-S) are summarized in Table 1. Pesticide application information, including the types of pesticides, and the time and the rate of pesticide application is presented in Tables 2a and 2b.

**4. Project Activities**

This research project had been a hot spot in the last four years on the Dryland Cropping Systems Annual Field Days that were organized jointly by SPARC, Wheatland Conservation Areas Inc., and SAFRR. The annual event received an estimated count of 1400 visitors, including producers, industrial representatives, extension agrologists, and researchers. During the past four summers (1999-2002), this project welcomed international scientists and researchers (from Argentine, Australia, Israel, and US), regional delegates and industrial representatives, and local producers' groups. This experiment also served as a "training ground" site for the staff of the Saskatchewan Crop Insurance Corporation (SCIC) in 2001. SCIC staff learned how to identify various types of crop injury symptoms that may be caused by diseases, hail, drought, nutrient deficiency, etc. In 2000, the experimental plots were used as a class site for the Saskatchewan Wheat Pool and Westco organized "Field Diagnosis School" in which CCA and extensionists received hand-on training experience.

# 5. Major Findings:
# Part I -- Growth and Yield Responses

### *A) Inoculation with Rhizobium vs. Non-inoculation.*

Inoculation with rhizobium tended to reduce plant population significantly in 5 of the 6 site-years for desi-chickpea, but this trend was not evident in kabuli-chickpea or lentil (Table 5a). The reasons for this effect are not known, but one may suspect that there might exist some interactions between seed coat and rhizobial bacteria. The chemical components (pigment) of the desi seed coat might be more sensitive to the rhizobial bacteria compared to kabuli chickpea or lentil. More research is needed to address these different responses to rhizobium inoculation among pulse species/classes.

Inoculation of pulses with rhizobium is indispensable to maximize seed yield potential (Table 5a). Inoculation increased seed yield by an average of 35% in desi chickpea and 23% in lentil. Kabuli chickpea showed lower responses to inoculation, with seed yield increase ranging from 0.9 to 30%, with an average of 7% across the six site-years. Kabuli chickpea grown on the clay soil at Stewart Valley responded strongly to rhizobium inoculation than kabuli grown on loam soil at Swift Current. These results imply that kabuli chickpea grown on loam soil has stronger ability to fix their own N or stronger rooting systems to uptake the needed N from deep soil layers even if a rhizobium source is not provided.

Nevertheless, a 7% yield increase in kabuli chickpea with rhizobium inoculant is still economically significant, because this level of yield increase translates into an average increase of net return by $15 to $20/ac (based on averaged production level at swift Current). This value is far more than the cost of use for inoculant at the recommended rate. However, more research is definitely needed to elucidate whether a high rate of nitrogen application in kabuli chickpea would produce a higher seed yield than use of rhizobium inoculant under the semiarid growing conditions.

Rhizobial inoculation did not impact harvestability in terms of plant height, lowest pod height, or days to maturity for any of the three crops (Table 5b), except for desi chickpea that had a positive response of plant height to inoculation. On average, the desi plants inoculated with rhizobium had an average of 1.9 cm taller than plants that were not inoculated.

### *B) Peat-based Powder versus Granular Inoculants*

There was a tendency for plant density to decrease in plots inoculated with peat-based powder, compared to plots that received granular form of inoculation (Table

6a). This trend was found in both types of chickpeas, suggesting that peat-based powder inoculating the seed may produce certain degree of damage to the emerging seedlings. However, such a trend was not evident in lentil. More research is needed to determine this effect further.

On average, the granular form of rhzobium inoculant increased seed yield by 7% in chickpeas and 8% in lentil, as compared to peat-based powder formulation (Table 6a). Lentil plants showed a wide range of responses with seed yields increases ranging from 3 to 38%, except one site (2000 SC) where yield was decreased with granular form. Therefore, use of granular form of inoculant in both chickpea and lentil is strongly encouraged. The extra cost associated with the use of a granular inoculant product is less than the extra net income due to increased seed yield from granular inoculation. Inoculant formulation did not affect average kernel weight (Table 6a). The two different forms of rhizobium inoculants produced almost identical responses in terms of plant height, lowest pod height, and days to maturity (Table 6b).

***C) Placement of Granular Inoculant***

In this study, the granular form of rhizobium inoculant was placed in the seed-row and was compared with side-banding treatments. The results showed that the placement of rhizobium inoculant did not affect plant establishment for any of the three pulses (Table 7a). Seed yield or seed weight was not related to the inoculant placement in general, although in 4 of the 6 site-years the seed yield of desi chickpea was slightly (2.3%) higher for seed-row application compared to side-band treatments. No differences were found between the two application methods for kabuli chickpea or lentil. The placement of granular inoculant did not affect harvestability for any of the pulses tested (Table 7b).

Use of granular forms of rhizobial inoculant allowed producers to inoculate the soils efficiently instead of the seed, resulting in a more uniform distribution of rhizobia in the soil profile. The fact that the inoculant placement, either applied in the seed-row or was side-banded, had no effects on plant establishment, seed yields, or harvestability, encourages pulse growers to adopt this practice with whatever their seeding systems allow them to do.

***D) Starter N***

Prior to seeding in each year, the residual soil N was measured to a 120-cm soil depth in several fields, then the field with a low to medium level of nutrients was selected for conducting this experiment. The residual soil N ranged from 10 to 20 kg N $ha^{-1}$ (except 2002 Swift Current) and residual soil P ranged from 10 to 28 kg $P_2O_5$ $ha^{-1}$; the variation among site-years was due to a different piece of land used

each year for the experiment (Table 1).

Starter N at the rate of 15 kg N $ha^{-1}$, compared to non-N check treatment, did not affect plant establishment in chickpea or lentil, although the N application slightly reduced lentil plant population (Table 8a). Lentil has a thinner seed coat than desi chickpea, and thinner seed coat might be more sensitive to the Starter N that was applied in the seed-row.

Starter N increased seed yields by an average of 2% for desi chickpea, 5% for kabuli chickpea, and 4% for lentil (Table 8a), though the increases in seed yield were found in 5 out of 6 site-years and was statistically significant for kabuli chickpea only. Kabuli chickpea showed the greatest responses to Starter-N. This was coincident to the fact that kabuli chickpea responded to rhizobial inoculant much less than desi chickpea (as described in the previous paragraph). These results strongly suggest that further study is needed to investigate the interactions between N rate and rhizobium inoculation in kabuli chickpea.

The application of Starter N improved harvestability by increasing plant height and the lowest pod height in all pulses studied (Table 8b). This increase in plant height and the lowest pod height was mainly due to applied N boosting vegetative growth in the early growth stage, particularly before flowering. We observed in the field that plots that received Starter N were greener, more vigorous before flowering than plots that did not receive N. Starter N accelerated plant maturity by a merely 0.5 to 0.7 days, which is marginal, despite statistically significant in most cases of the trials.

***E) Starter P and P rates***

In general, Starter P at the rate of 15 kg $P_2O_5$ $ha^{-1}$, compared to non-P check treatment, did not affect any of the growth- or yield-related variables measured in this study (Table 9a and 9b). There was no yield response to Starter P in chickpea, but Starter-P increased lentil seed yield in 4 out of 6 site-years with an average of 4%. Kabuli chickpea showed a substantial increase in lowest pod height with Starter-P (Table 9b), which improved harvestability by 5%.

In an adjacent trial where three rates of phosphorous (0, 17, and 34 kg $P_2O_5$ $ha^{-1}$) were used to determine if a higher rate of fertilizer P would affect the growth and seed yields of chickpea. The results indicate that when kabuli chickpea was seeded in the mid- to late-May in the Brown soil zone, P at the rate of 34 kg $P_2O_5$ $ha^{-1}$, compared to 0 and 17 kg $P_2O_5$ $ha^{-1}$, increased the proportion of the $\geq$9-mm diameter seeds from 54% to 59% in the harvested seedlot, implying an increase of the price premiums from the large-sized seed. However, this response was not observed when kabuli was seeded at an early-May seeding date. The earlier-seeded chickpea had a longer period of time to develop stronger rooting systems that help to uptake

nutrients from deep soil layers, thus no effect of fertilizer P application on kabuli seed size was detected.

### F) *Penicillium bilaii* Effect

*Penicillium bilaii*, a soil-isolated fungus, is believed to make residual soil P available to emerging seedlings. Studies on cereal and oilseed crops have shown that in some cases, but not all, the use of *Penicillium bilaii* may boost seedling emergence and vegetative growth in the early stage. There was no information available whether pulse crops would respond to this product under the semiarid growing conditions. In the present study, we applied **JumpStart** (that contains *Penicillium bilaii*) at the recommended rate with the recommended methods, and compared with the treatments that received no JumpStart, without or with an additional Starter-N or Starter-P applied. The objective was not to evaluate how the product would perform, rather to determine the best options that the pulse producers could adopt to produce a maximum seed yield and net return.

The results indicate that the use of *Penicillium bilaii* did not affect plant establishment or seed yield for any of the three pulse crops tested (Table 10a). *Penicillium bilaii* did not result in any improvement to harvestability (such as plant height, lowest pod height, maturity) for any pulse crops (Table 10b). Only positive response was found in 1999 at Swift Current on desi crop where *Penicillium bilaii* increased desi seed yield by 11% (Table 10a), but not for kabuli or lentil. In 17 out of the 18 crop site-years, *Penicillium bilaii* did not affect seedling emergence, plant growth, seed yield, or harvest conditions.

*Penicillium bilaii* is believed to make soil P more available for plants mainly by lowering soil pH and dissolving soil calcium P. However, work conducted by Selles (1993) in Swift Current and by Soon (1991) showed that at the rates of fertilizer P used in the prairie soils availability of inorganic P forms is controlled by sorption processes rather than the solubility of calcium forms of phosphate. This may partly explain why *Penicillium bilaii* did not show responses in the present study with annual pulses.

**TagTeam** is a product containing both the soil-isolated fungus *Penicillium bilaii* and rhizobium bacteria needed for $N_2$-fixation. In the present study, plots that received TagTeam were compared with plots that received no rhizobium or the plots receiving other brand of rhizobium inoculant, under the semiarid growing conditions.

Plots that received TagTeam, compared to the plots that did not receive any rhizobium inoculant, increased seed yield by 21% for desi chickpea, 9% for kabuli chickpea, and 32% for lentil (Table 13a). These levels of yield increases were identical to those where plots received other brand of rhizobium inoculant without

*Penicillium bilaii*. These results indicate that *Penicillium bilaii* did not have any impacts to seed yields of pulse crops in the semiarid conditions. These observations were true for lentil, desi chickpea, and kabuli chickpea (Table 14a). Further analyses to the six site-years of data indicate that TagTeam did not improve harvest conditions such as plant height and days to maturity. It should be noted that the rhizobial strains used in TagTeam are not the same as those used in the comparison inoculant and this might cause bias. Further study is needed to make sound conclusions.

## 5. Major Findings: Part II
## Root Nodulation of Lentil and Chickpea

Lentil and chickpea can fix nitrogen from the atmosphere when the plant forms active root nodules. These root nodules are formed when the proper strain of *Rhizobium* bacterial inoculant is provided for the crop and together the plant and bacteria form a symbiotic relationship. Not enough active nitrogen-fixing root nodules can result in substantially decreased plant production and seed yield potential (Green and Biederbeck 1995).

To evaluate the effect of inoculant form and fertilization on root nodulation under the semiarid growing environment, an intensive study was conducted. At flowering, plant roots were excavated to a soil depth of approximately 20 cm. Ten plants were collected from each plot. The roots, with adhering soil, were placed into water and soaked to aid soil removal while retaining the nodules on the roots. After initial soil removal, the plants were then placed in bags with some water and transferred to a cold room (4 C) until the time of evaluation within 48 h. Root nodules were counted and dry mass determined.

### Nodules Numbers and Mass

An evaluation of root nodulation of chickpea was conducted in 1999 utilizing the nodulation rating scheme developed by Rice and Clayton (1996), which had previously shown to work for large-seeded annual legumes such as pea. It was soon discovered however that this scheme did not work for either chickpea type. After this, it was determined that to properly evaluate subsequent chickpea nodulation a different approach would have to be used. For the remaining years of the study, total nodule number and total nodule mass were determined on select treatments due to the limited help available for this very labour and time intensive work.

Only 2001 and 2002 data for nodulation was used for these evaluations due to inoculation errors at the time of seeding in 2000. Due to labour and time constraints, lentil nodules were not determined in 2002.

Interestingly, at all sites-years, both chickpea types had some nodules found on non-inoculated plots at the time of sampling. Other researchers in Saskatchewan have found similar results when conducting inoculum research on chickpea (Kyei-Boahen 2000).

***Inoculation with rhizobia vs nodulation***

Inoculation with peat powder or granular rhizobial inoculants clearly increased the number of nodules and nodule dry mass of both chickpeas and lentil overall (Table 17a). The average increase in nodule number of desi was over 72% while for kabuli and lentil it was even higher. Increases in nodule dry mass averaged over 72% as well. This large increase in nodule number and dry mass clearly shows that rhizobial inoculation is essential increasing nodulation that in turn leads to greater yields.

***Inoculant Formulation vs nodulation***

Inoculant form which influences inoculant placement was an important part of this study. Seed applied peat powder has been traditionally used on many pulse crops however the ability of the more recently developed granular inoculants to increase nodulation has been shown (Rice and Lupwayi, personal communication). Desi chickpea and lentil showed large increases in nodule number and dry mass in all site-years (Table 17b). However kabuli chickpea was found to have an overall lower response to the granular inoculant. This research supports notion that "granular inoculation of legumes is often better and never worse than seed applied peat" (Rice, personal communication).

***N & P fertilization vs nodulation***

Adequate plant-available phosphorus is suggested to be essential for not limiting legume root nodulation and, in turn, production. In this study, the addition of $P_2O_5$ was found to consistently decrease the amount of nodules formed by the pulses (Table 17c). The evaluation of this was conducted using granular inoculated treatments with and without P. The granular inoculant was placed in the seed row where as the fertilizer was side-banded thus the reduction in nodules can not be attributed to rhizobial inoculant/fertilizer contact. Other potential causes of this reduction have not been determined.

The effect on nodule dry mass varied among the pulses with lentil and desi chickpea both showing reductions in 2001. Kabuli response depended on the site in 2001. In 2002, both chickpea types showed increases in nodule mass. Bremer et al. (1989) found that nitrogen fixation and yield in lentil was not affected by P. Our study found no difference in yield either therefore the reduction in nodule number and variable response of nodule dry mass does not appear to have limited nitrogen fixation or production.

The addition of starter nitrogen was found to reduce the number of nodules in both kabuli chickpea and lentil (Table 17d). However, the response by desi chickpea was more variable. The reduction in nodule dry mass was consistent for all the pulses in 2001 however in 2002 the chickpeas showed very small differences. This reduction in nodule number and mass can be expected since with more soil N available the plant does not require as much $N_2$-fixation and therefore fewer nodules.

***TagTeam vs nodulation***

Root nodulation as effected by the presence of *Penicillium bilaii*, a phosphorus-solubilizing fungi, was found to be variable at best when compared to rhizobially inoculated pulses with or without added P (Table 17e). The nodule number and dry mass was not different or decreased with the use of TagTeam, which contains a rhizobial inoculant and the *P. bilaii* together, compared to the treatment that did not have *P. bilaii*. It should be noted that the rhizobial strains used in TagTeam are not the same as those found in the comparison inoculant and this may be contributing to the differences. Further study is needed to make sound conclusions.

**References**

Green, B.J. and Biederbeck, V.O. (eds.) 1995. Farm facts: Soil Improvement with Legumes, including legumes in crop rotations. Canada-Saskatchewan Agreement on Soil Conservation Bulletin, ISSN0840-9447, 20 pp.

Bremer, E., Van Kessel, C., and Karamanos, R. 1989. Inoculant, phosphorus and nitrogen responses of lentil. Can. J. Plant Sci. 69: 691-701.

Kyei-Boahen, S. 2000. Evaluation of granular *Rhizobium* inoculant for chickpea. Ph. D. dissertation, University of Saskatchewan, Saskatoon, Saskatchewan.

Rice, W.A. and Clayton, G.W. 1996. Northern Agricultural Research Centre, Agriculture and Agri-Food Canada.

Saskatchewan Agriculture, Food and Rural Revitalization. 2002. Chickpea in Saskatchewan."http://www.agr.gov.sk.ca/docs/crops/pulses/production_information/chickpea2002.asp"

Selles, F. 1993. Residual effect of phosphorus fertilizer when applied with the seed or banded. Commun. Soil Sci. Plant Anal. 24: 951-960.

Soon, Y.K. 1991. Solubility and retention of phosphate in soils of the Northwestern Canadian Prairie. Can. J. Soil Sci. 71: 453-463.

**(d) Personnel**

| Name | Title | Months involved/year |
|---|---|---|
| Ray Leshures | technician | 9 |
| Greg Ford | technician | 5 |
| Ginny Cooke | casual labourer | 1 |

**(e)Equipment**

None

**(f) Project Developed Materials**

See publication list

**(g) Project Photos**

N/A

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**(j) Technology-Transfer Releases from this and related projects:**

1. Gan, Y., McConkey, B.G., Miller, P.R., R.P. Zentner and C.L. McDonald. 2000. Chickpea in the semiarid cropping systems. Page 13-21. In Proc. Soils and Crops Workshop 2000, Saskatoon, Sask. Feb 24 & 25, 2000.

2. Gan, Y. and G. Noble. 2000. Chickpea in Southwestern Saskatchewan -- Potential and Risks. Page 8-9. In Proc. Third Pulse Crop Research Workshop. Winnipeg, MB. 19-21, November 2000.

3. Gan, Y. 2001. Fitting chickpeas in the semiarid cropping systems. Pages 20-21. *In* Proc. Dryland Crop Rotation Conference. Moose Jaw, Saskatchewan, Canada. . March 1-2, 2001.McConkey, B., Gan, Y., P. Miller, and R. Zentner. 2001. Building successful crop rotations for the semiarid prairie. Pages 18-19. *In* Proc. Dryland Crop Rotation Conference. Moose Jaw, Saskatchewan, Canada. March 1-2, 2001.

4. Gan, Y., R. Zentner, P. Miller, B. McConkey, and C. McDonald. 2001. Chickpeas on fallow versus stubble in the Brown Soil Zone. Page 346. *In* Proc. Soils and Crops Workshop 2001, Saskatoon, Sask. Feb 22 & 23, 2001.

5. Gan, Y. and B. Nybo. 2001. Best management practices for chickpea. Pages 42-45. *In* Proc. Pulse Days 2001. Saskatchewan Pulse Growers. Saskatoon, Sask. Jan 8 -9, 2001.

6. Liu, Puhai and Y. Gan. 2001. Morphological Plasticity of Chickpea vs Water Availability. Pages 5-6. *In* Proc. North American Pulse Improvement Association, biannual conference, Fargo, ND. Oct. 28-30, 2001.

7. McConkey, B., Selles, F, Gan, Y., and Lemke, R. 2001. Nitrogen deficiency, and the value of pulse for low-disturbance direct seeding. p. 117 *In* Proceedings of the 13th Annual Meeting, Conf, and Trade Show of the Saskatchewan Soil Conservation Association, Feb 14-15, Saskatoon, SK.

8. McConkey, B., Selles, F, Gan, Y., and Lemke, R. 2001. Nitrogen deficiency, and the value of pulse for low-disturbance direct seeding. p. 84 *In* Proceedings of the Farm Tech 2001, Jan 30 - Feb 1, Red Deer, AB.

9. Gan, Y., Miller, P.R., McConkey, B.G., Zentner, R.P. and McDonald, C.L. 2002. Optimum plant population density for chickpea in a semiarid environment. *In* Proc. Soils and Crops Workshop 2002 (CD-ROM), University of Saskatchewan, Saskatoon, SK., Feb 21-22.

10. Gan, Y., Warkentin, T., Johnston, A., McDonald, C.L. and Poppy, L.B. 2002. Chickpea pod infertility: a potential of improving seed yield. *In* Proc. Soils and Crops Workshop 2002 (CD-ROM), University of Saskatchewan, Saskatoon, SK., Feb 21-22.

11. Hanson, K.G. and Gan, Y. 2002. Development of a rating scheme to evaluate root nodulation in chickpea (*Cicer arietinum* L.). *In* Proc. Soils and Crops Workshop 2002 (CD-ROM), University of Saskatchewan, Saskatoon, SK., Feb 21-22.

12. Hanson, K.G., Gan, Y. and McDonald, C.L. 2002. Developing a method of root nodule evaluation as an yield indicator for kabuli chickpea. P. 96. *In* Proc. Pulse Days 2002, Saskatoon, Saskatchewan. Jan. 7-8, 2002.

13. Gan, Y.T. and McDonald, C.L. 2002. Assessment of Chickpea Seed Yield Potential at the Podding Stage. Pp.154-157. *In* Proc. 4th Canadian Pulse Research Workshop, Edmonton, Canada, Dec 8-10, 2002.

14. Gan, Y.T. and McDonald, C.L. 2002. Severity of Ascochyta Blight versus Leaf Type of Chickpea. Pp.271-274. *In* Proc. 4th Canadian Pulse Research Workshop, Edmonton, Canada, Dec 8-10, 2002.

15. Gan, Y.T., Miller, P.R., McConkey, B.G., Zentner, R.P. and McDonald, C.L. 2002. Field Pea, Kabuli, and Desi Chickpea Respond Differently to Plant Population Density. Pp.317-320. *In* Proc. 4th Canadian Pulse Research Workshop, Edmonton, Canada, Dec 8-10, 2002.

16. Hanson, K.G. and Gan, Y.T. 2002. Root Nodule Indicators for Assessing Potential Crop Productivity of Chickpea (*Cicer arietinum*). Pp. 140-144. *In* Proc. 4th Canadian Pulse Research Workshop, Edmonton, Canada, Dec 8-10, 2002.

17. Hanson, K., and Gan, Y. 2003. Fertilizer treatments may affect desi and kabuli chickpeas differently. P.77. *In* Proc. Pulse Days 2003 - Meeting the challenge: Opportunities and pressures within the pulse industry. Saskatoon, SK. Jan. 6-7, 2003.

18. Gan, Y., McConkey, B.G., Zentner, R.P., Cutforth, H. and McDonald, C.L. 2002. Pulses in cropping systems. Invited presentation to Extension Agrologists and Producers Meeting, organized jointly by Saskatchewan Agriculture and Food and Saskatchewan Pulse Growers, Swift Current, SK. Jan. 28, 2002.

19. Gan, Y., McConkey, B.G., Zentner, R.P., Cutforth, H. and McDonald, C.L. 2002. Agronomy of annual pulses in cropping systems. Invited presentation to Extension Agrologists and Producers Meeting, organized jointly by Saskatchewan Agriculture and Food and Saskatchewan Pulse Growers, Assiniboia, SK. Jan.30, 2002.

20. Gan, Y., McConkey, B.G., Zentner, R.P., Cutforth, H. and McDonald, C.L. 2002. Agronomy of pulses in cropping systems. Invited presentation to Swift Current Marketing Club. Swift Current, SK. Nov. 20, 2002.

21. Gan, Y. 2002. Agronomy of annual pulses in cropping systems. *In* Proc. 1st Annual Producer Agronomy Training School, Semiarid Prairie Agricultural Research Centre, Swift Current, SK., Dec 4-5, 11 pp.

22. Zentner, R.P., McConkey, B.G. and Gan, Y. 2002. Economics and risk management of cropping systems. *In* Proc. 1st Annual Producer Agronomy Training School, Semiarid Prairie Agricultural Research Centre, Swift Current, SK., Dec 4-5, 14 pp.

23. Zentner, Bob, McConkey, Brian, and Gan, Yantai. 2002. Building successful crop rotations. Pioneer Coop Farmer Appreciation Days, Swift Current, SK., Dec. 19, 10 pp.

24. Gan, Y. and McDonald, C.L. 2002. Chickpea genotype population canopy study. Page 11 *In* Proc. Dryland Cropping Systems Field Day 2002. Swift Current, SK. July 4, 2002.

**Table 1. Agronomic information for chickpea and lentil studies conducted at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year | Cultivar | Seeding date | | Soil temperature (°C) | | Soil residual N-P-K-S (kg ha$^{-1}$) | Kernel weight (mg seed$^{-1}$) | Seeding rate (kg ha$^{-1}$) | Harvest date | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | SC | SV | SC | SV | | | | SC | SV |
| 1999 | Laird | 25 May | N/A | 17 | N/A | 16-20-0-0 (SC) | 69 | 99 | 10 Sep | N/A |
| | Myles | 26 May | N/A | 17 | N/A | 21-25-0-0 (SC) | 181 | 103 | 14 Sep | N/A |
| | Sanford | 26 May | N/A | 17 | N/A | 16-16-0-0 (SC) | 499 | 224 | 17 Sep | N/A |
| 2000 | CDC Glamis | 3 May | 4 May | 16 | 12 | 9-28-0-0 (SC)<br>18-10-0-0 (SV) | 60 | 84 | 11 Aug | 17 Aug |
| | Myles | 3 May | 4 May | 16 | 12 | 10-26-0-0 (SC)<br>17-10-0-0 (SV) | 178 | 100 | 28 Aug | 8 Sep |
| | CDC Xena | 4 May | 5 May | 16 | 13 | 11-21-0-0 (SC)<br>17-10-0-0 (SV) | 554 | 244 | 1 Sept | 1 Sep |
| 2001 | CDC Glamis | 26 Apr | 30 Apr | 10 | 9 | 15-18-0-0 (SC)<br>17-10-0-0 (SV) | 63 | 88 | 10 Aug | 10 Aug |
| | Myles | 27 Apr | 30 Apr | 10 | 9 | 15-18-0-0 (SC)<br>17-10-0-0 (SV) | 170 | 95 | 21 Aug | 10 Sep |
| | CDC Xena | 26 Apr | 30 Apr | 10 | 9 | 15-18-0-0 (SC)<br>17-10-0-0 (SV) | 489 | 246 | 11 Sep | 12 Sep |
| 2002 | CDC Glamis | N/A | 17 May | N/A | 11 | 20-18-0-0 (SV) | 61 | 85 | N/A | 10 Sep |
| | Myles | 16 May | 17 May | 11 | 11 | 45-28-0-0 (SC)<br>18-16-0-0 (SV) | 172 | 96 | 23 Oct | 24 Oct |
| | CDC Xena | 16 May | 17 May | 11 | 11 | 45-28-0-0 (SC)<br>21-21-0-0 (SV) | 496 | 218 | 15 Oct | 26 Sep |

**Table 2a. Pesticide application in chickpea and lentil studies conducted at Swift Current, Saskatchewan, 1999-2002.**

| | | Herbicide Application | | | Fungicide Application |
|---|---|---|---|---|---|
| Year, site | Previous fall | Pre-seeding | Pre-emergent | In-crop | In-crop |
| 1999, Swift Current | None | May 6<br>glyphosate,0.89 kg $ha^{-1}$<br>May 18<br>trifluralin,1.1 kg $ha^{-1}$ | June 1<br>glyphosate,0.89 kg $ha^{-1}$ | September 1(lentils only)<br>diquat, 0.40 kg $ha^{-1}$<br>September 9 (all crops)<br>diquat, 0.40 kg $ha^{-1}$ | July 21 (desi+kabuli)<br>chlorothalonil,1.48 kg $ha^{-1}$<br>August 11 (desi+kabuli)<br>chlorothalonil,1.98 kg $ha^{-1}$ |
| 2000, Swift Current | None | April 25<br>glyphosate, 0.44 kg $ha^{-1}$<br>trifluralin,1.1 kg $ha^{-1}$ | None | May 25<br>metribuzin,0.16 kg $ha^{-1}$<br>May 26<br>sethoxydim,0.21 kg $ha^{-1}$<br>August 9 (lentils only)<br>diquat, 0.40 kg $ha^{-1}$ | June 29, July 12, July 21<br>(desi+kabuli)<br>chlorothalonil,1.73 kg $ha^{-1}$ |
| 2001, Swift Current | None | April 12<br>ethalfluralin,0.9 kg $ha^{-1}$<br>April 26<br>glyphosate,0.44 kg $ha^{-1}$ | May 3<br>glyphosate,0.44 kg $ha^{-1}$<br>imazethapyr,0.01 kg $ha^{-1}$ | July 20 (lentil+desi)<br>deltamethrin,0.007 kg $ha^{-1}$<br>July 30 (kabuli)<br>deltamethrin,0.01 kg $ha^{-1}$<br>Aug 3 (lentils)<br>diquat, 0.36 kg $ha^{-1}$<br>Aug 30 (kabuli)<br>diquat, 0.44 kg $ha^{-1}$ | June 22 (desi+kabuli)<br>Aug 2 (kabuli)<br>chlorothalonil,1.98 kg $ha^{-1}$<br>July 3,23 (desi+kabuli)<br>azoxystrobin,0.12 kg $ha^{-1}$ |
| 2002, Swift Current | None | April 17<br>ethalfluralin,0.9 kg $ha^{-1}$<br>April 30<br>glyphosate,0.89 kg $ha^{-1}$ | May 25<br>glyphosate,0.44 kg $ha^{-1}$<br>imazethapyr,0.01 kg $ha^{-1}$ | June 14<br>sethoxydim,0.21 kg $ha^{-1}$<br>July 27<br>deltamethrin,0.006 kg $ha^{-1}$<br>Oct 3 (kabuli)<br>diquat, 0.41 kg $ha^{-1}$<br>Oct 9 (desi)<br>diquat, 0.41 kg $ha^{-1}$ | June 25<br>chlorothalonil,1.98 kg $ha^{-1}$<br>July 8, July 30, Aug 14<br>chlorothalonil,1.48 kg $ha^{-1}$<br>July 16<br>azoxystrobin,0.25 kg $ha^{-1}$<br>Aug 29<br>azoxystrobin,0.12 kg $ha^{-1}$ |

Note: all chemicals are in a.i. units.

**Table 2b. Pesticide application in chickpea and lentil studies conducted at Stewart Valley, Saskatchewan, 2000-2002.**

| | | Herbicide Application | | | Fungicide Application |
|---|---|---|---|---|---|
| Year, site | Previous fall | Pre-seeding | Pre-emergent | In-crop | In-crop |
| 2000, Stewart Valley | Nov 8/99<br>2,4-D 500 amine, 0.56 kg $ha^{-1}$ | April 20<br>trifluralin , 1.1 kg $ha^{-1}$<br>April 24, May 2<br>glyphosate, 0.44 kg $ha^{-1}$ | May 9<br>glyphosate, 0.44 kg $ha^{-1}$ | May 25<br>metribuzin, 0.16 kg $ha^{-1}$<br>May 29<br>sethoxydim, 0.21 kg $ha^{-1}$<br>August 11(lentils only)<br>diquat, 0.40 kg $ha^{-1}$<br>August 31(desi only)<br>diquat, 0.40 kg $ha^{-1}$ | June 30, July 13<br>chlorothalonil, 1.73 kg $ha^{-1}$ |
| 2001, Stewart Valley | None | April 27<br>ethalfluralin, 0.90 kg $ha^{-1}$ | May 3<br>glyphosate, 0.44 kg $ha^{-1}$<br>imazethapyr,0.012 kg $ha^{-1}$ | June1, June20<br>sethoxydim, 0.21 kg $ha^{-1}$<br>July 30<br>deltamethrin, 0.01 kg $ha^{-1}$<br>Aug 3(lentils)<br>diquat, 0.36 kg $ha^{-1}$<br>Aug 27 (desi),<br>diquat, 0.44 kg $ha^{-1}$<br>Aug 31 (kabuli)<br>diquat, 0.44 kg $ha^{-1}$<br>Aug 31 (desi)<br>glyphosate, 0.89 kg $ha^{-1}$ | June 27 (desi+kabuli)<br>chlorothalonil, 1.98 kg $ha^{-1}$<br>July 10,30 (desi+kabuli)<br>azoxystrobin, 0.124 kg $ha^{-1}$ |
| 2002, Stewart Valley | Oct 11/01<br>glyphosate,<br>0.89 kg $ha^{-1}$<br>2,4-D 600 ester, 0.55 kg $ha^{-1}$ | April 18<br>ethalfluralin, 0.90 kg $ha^{-1}$ | May 27<br>glyphosate, 1.78 kg $ha^{-1}$<br>imazethapyr,0.012 kg $ha^{-1}$ | June 24, sethoxydim, 0.21 kg $ha^{-1}$<br>July 11, July 25, deltamethrin, 0.01 kg $ha^{-1}$; Aug 7, deltamethrin, 0.007 kg $ha^{-1}$<br>Aug 7, glyphosate, 0.67 kg $ha^{-1}$<br>Aug 26 (lentils), diquat, 0.41 kg $ha^{-1}$<br>Sept 18, diquat, 0.41 kg $ha^{-1}$ | June 25 (desi+kabuli)<br>chlorothalonil, 1.98 kg $ha^{-1}$<br>July 11 (desi+kabuli)<br>chlorothalonil, 1.48 kg $ha^{-1}$<br>July 22 (desi+kabuli)<br>azoxystrobin, 0.19 kg $ha^{-1}$<br>Aug 7<br>azoxystrobin, 0.124 kg $ha^{-1}$ |

Note: all chemicals are in a.i. units.

**Table 3. Biomass sampling and growing degree-days measured for lentil (cv. Laird or CDC Glamis), desi chickpea (cv. Myles), and kabuli chickpea (cv. Sanford or CDC Xena) at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | | Days from seeding to: | | | | | Growing degree days (5°C basis) from seeding to: | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year, site | Variety | Pre-flower | Early flower | Late flower | Mid-pod | Mature | Pre-flower | Early flower | Late flower | Mid-pod | Mature |
| | Laird | 49 | 63 | . | . | . | 458 | 624 | . | . | . |
| 1999, SC | Myles | 36 | 50 | 64 | . | 97 | 322 | 469 | 642 | . | 1113 |
| | Sanford | 41 | 55 | 70 | . | 100 | 365 | 513 | 708 | . | 1115 |
| | CDC Glamis | 55 | 70 | 84 | . | 98 | 377 | 562 | 754 | . | 980 |
| 2000, SC | Myles | 50 | 70 | 84 | 98 | 108 | 337 | 562 | 754 | 980 | 1116 |
| | CDC Xena | 56 | 69 | 83 | 97 | 107 | 388 | 555 | 747 | 973 | 1108 |
| | CDC Glamis | 57 | 70 | 84 | . | 98 | 422 | 601 | 802 | . | 1029 |
| 2000, SV | Myles | 54 | 70 | 84 | 98 | 110 | 386 | 601 | 802 | 1029 | 1186 |
| | CDC Xena | 56 | 69 | 83 | 98 | 109 | 412 | 591 | 816 | 1040 | 1176 |
| | CDC Glamis | 56 | 75 | . | 89 | 100 | 443 | 714 | . | 921 | 1078 |
| 2001, SC | Myles | 54 | 74 | . | 88 | 103 | 423 | 705 | . | 912 | 1150 |
| | CDC Xena | 58 | 75 | 89 | 104 | 120 | 476 | 714 | 921 | 1159 | 1407 |
| | CDC Glamis | 53 | 72 | . | 86 | 96 | 427 | 688 | . | 896 | 1042 |
| 2001, SV | Myles | 51 | 72 | . | 86 | 100 | 401 | 688 | . | 896 | 1120 |
| | CDC Xena | 53 | 72 | 86 | 100 | 116 | 427 | 688 | 896 | 1120 | 1360 |
| | CDC Glamis | 40 | 56 | 69 | 83 | 97 | 355 | 589 | 808 | 954 | 1092 |
| 2002, SV | Myles | 40 | 56 | 69 | 83 | 146 | 355 | 589 | 808 | 954 | 1453 |
| | CDC Xena | 40 | 56 | 69 | 83 | 124 | 355 | 589 | 808 | 954 | 1425 |

**Table 4. Weather data for Swift Current and Stewart Valley, Saskatchewan, 1999-2002.**

| Site | Year | Growing Season | | | | |
|---|---|---|---|---|---|---|
| | | May | June | July | August | Mean/Total |
| | | Precipitation (mm) | | | | |
| **Swift CCurrent** | 1999 | 93.9 | 86.2 | 60.3 | 16.8 | 257 |
| | 2000 | 65.3 | 54.0 | 127.0 | 13.1 | 259 |
| | 2001 | 22.6 | 31.8 | 63.0 | 3.2 | 121 |
| | 2002 | 21.9 | 143.9 | 73.1 | 102.2 | 341 |
| **Stewart Valley** | 2000 | 15.2 | 51.1 | 108.5 | 15.5 | 190 |
| | 2001 | 11.7 | 7.4 | 60.2 | 0.5 | 80 |
| | 2002 | 3.6 | 102.4 | 79.2 | 75.2 | 260 |
| | **40-Yr Mean†** | **45.2** | **72.7** | **48.9** | **41.3** | **208** |
| | | Temperature ($^{o}$C ) | | | | |
| **Swift Current** | 1999 | 9.9 | 14.1 | 16.4 | 18.9 | 14.8 |
| | 2000 | 10.9 | 13.8 | 19.1 | 18.4 | 15.6 |
| | 2001 | 12.2 | 15.0 | 19.7 | 20.9 | 17.0 |
| | 2002 | 8.5 | 15.7 | 19.6 | 15.5 | 14.8 |
| **Stewart Valley** | 2000 | 10.9 | 14.3 | 19.7 | 18.3 | 15.8 |
| | 2001 | 12.8 | 15.2 | 19.6 | 20.3 | 17.0 |
| | 2002 | 8.7 | 16.5 | 19.8 | 15.8 | 15.2 |
| | **40-Yr Mean†** | **10.8** | **15.4** | **18.3** | **17.9** | **15.6** |

† Means from 1963 to 2002 at Swift Current, not available at Stewart Valley since the trials were on a producers field.

**Table 5a. Effect of rhizobium inoculation on growth and yields of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | No inoculant | Inoculant | Diff. % | *P* value | No inoculant | Inoculant | Diff. % | *P* value | No inoculant | Inoculant | Diff. % | *P* value |
| **Plant population (plants $m^{-2}$)** | | | | | | | | | | | | |
| 1999 SC | 50.0 | 39.1 | -21.8 | 0.01 | 36.5 | 32.5 | -11.0 | 0.29 | 70.3 | 61.3 | -12.8 | 0.04 |
| 2000 SC | 44.5 | 42.3 | -5.1 | 0.55 | 32.0 | 36.6 | 14.5 | 0.11 | 98.5 | 107.8 | 9.4 | 0.13 |
| 2001 SC | 48.5 | 36.3 | -25.3 | <0.01 | 34.8 | 37.9 | 9.0 | 0.25 | 92.5 | 96.9 | 4.7 | 0.53 |
| 2000 SV | 39.3 | 37.5 | -4.5 | 0.61 | 36.3 | 39.4 | 8.6 | 0.32 | 87.3 | 89.9 | 3.0 | 0.69 |
| 2001 SV | 35.0 | 39.4 | 12.5 | 0.10 | 36.8 | 33.0 | -10.2 | 0.26 | 127.3 | 114.0 | -10.4 | <0.01 |
| 2002 SV | 36.3 | 33.4 | -7.9 | 0.34 | 39.8 | 38.6 | -2.8 | 0.72 | 85.8 | 81.5 | -5.0 | 0.48 |
| **Mean** | **42.3** | **38.0** | **-10.1** | **<0.01** | **36.0** | **36.3** | **0.9** | **0.80** | **93.6** | **91.9** | **-1.8** | **0.47** |
| **Seed yield (kg $ha^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 1163 | 2363 | 103.2 | <0.01 | 1998 | 2107 | 5.5 | 0.35 | 1014 | 1047 | 3.3 | 0.67 |
| 2000 SC | 1646 | 1750 | 6.4 | 0.39 | 1857 | 1873 | 0.9 | 0.99 | 1745 | 1773 | 1.6 | 0.73 |
| 2001 SC | 557 | 558 | 0.2 | 0.98 | 554 | 562 | 1.5 | 0.89 | 248 | 346 | 39.6 | 0.08 |
| 2000 SV | 1851 | 2093 | 13.0 | 0.14 | 2470 | 2492 | 0.9 | 0.70 | 1359 | 1553 | 14.3 | 0.19 |
| 2001 SV | 648 | 1027 | 58.5 | <0.01 | 752 | 974 | 29.5 | <0.01 | 210 | 547 | 160.5 | <0.01 |
| 2002 SV | 1526 | 2030 | 33.0 | <0.01 | 1798 | 2206 | 22.7 | 0.04 | 691 | 1066 | 54.3 | <0.01 |
| **Mean** | **1229** | **1664** | **35.4** | **<0.01** | **1567** | **1672** | **6.7** | **0.02** | **847** | **1040** | **22.8** | **<0.01** |
| **Kernel weight (mg $seed^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 158 | 182 | 15.3 | <0.01 | 388 | 391 | 1.0 | 0.74 | 58 | 57 | -2.2 | 0.21 |
| 2000 SC | 166 | 170 | 2.2 | 0.51 | 452 | 450 | -0.3 | 0.88 | 57 | 54 | -4.9 | 0.09 |
| 2001 SC | 203 | 204 | 0.2 | 0.86 | 515 | 523 | 1.5 | 0.24 | 68 | 71 | 4.2 | 0.09 |
| 2000 SV | 185 | 192 | 3.6 | 0.16 | 489 | 484 | -1.0 | 0.39 | 62 | 60 | -2.7 | 0.04 |
| 2001 SV | 186 | 202 | 8.6 | <0.01 | 495 | 523 | 5.7 | <0.01 | 66 | 71 | 8.0 | <0.01 |
| 2002 SV | 175 | 182 | 4.0 | 0.06 | 500 | 515 | 3.0 | 0.29 | 57 | 66 | 16.5 | <0.01 |
| **Mean** | **175** | **187** | **6.5** | **<0.01** | **459** | **464** | **1.1** | **0.08** | **61** | **61** | **0.0** | **<0.01** |

**Table 5b. Effect of rhizobium inoculation on harvestability of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV) Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | No inoculant | Inoculant | Diff. % | *P* value | No inoculant | Inoculant | Diff. % | *P* value | No inoculant | Inoculant | Diff. % | *P* value |
| **Plant height (cm)** | | | | | | | | | | | | |
| 1999 SC | 37.4 | 41.3 | 10.4 | 0.02 | 54.2 | 54.2 | 0.0 | 1.00 | . | . | . | . |
| 2000 SC | 46.8 | 46.8 | 0.0 | 1.00 | 47.3 | 45.6 | -3.4 | 0.48 | 38.8 | 42.0 | 8.4 | 0.08 |
| 2001 SC | 29.3 | 29.6 | 1.3 | 0.71 | 31.8 | 31.6 | -0.4 | 0.93 | 30.8 | 30.5 | -0.8 | 0.79 |
| 2000 SV | 44.8 | 45.6 | 2.0 | 0.62 | 49.8 | 52.3 | 5.0 | 0.14 | 38.5 | 40.6 | 5.5 | 0.32 |
| 2001 SV | 26.5 | 28.3 | 6.6 | 0.04 | 31.3 | 30.1 | -3.6 | 0.27 | 28.3 | 29.6 | 4.9 | 0.16 |
| 2002 SV | 37.5 | 41.1 | 9.7 | 0.03 | 33.5 | 36.1 | 7.8 | 0.03 | 37.5 | 36.5 | -2.7 | 0.23 |
| **Mean** | **37.0** | **38.9** | **5.0** | **<0.01** | **41.8** | **42.2** | **0.9** | **0.57** | **34.8** | **35.9** | **3.2** | **0.09** |
| **Lowest pod height (cm)** | | | | | | | | | | | | |
| 1999 SC | 16.4 | 19.2 | 17.1 | <0.01 | 33.8 | 32.4 | -4.1 | 0.27 | | | | |
| 2000 SC | 17.3 | 17.1 | -0.7 | 0.90 | 26.3 | 23.9 | -9.0 | 0.03 | | | | |
| 2001 SC | 15.8 | 16.3 | 3.2 | 0.69 | 16.8 | 14.6 | -12.7 | 0.29 | ----------not measured---------- | | | |
| 2000 SV | 17.5 | 18.3 | 4.3 | 0.41 | 25.3 | 26.8 | 5.9 | 0.30 | | | | |
| 2001 SV | 15.0 | 15.3 | 1.7 | 0.85 | 15.8 | 13.1 | -16.7 | 0.09 | | | | |
| 2002 SV | 13.5 | 13.8 | 1.9 | 0.74 | 16.3 | 17.8 | 9.2 | 0.08 | 14.0 | 12.9 | -8.0 | 0.24 |
| **Mean** | **15.9** | **16.7** | **5.2** | **0.09** | **22.8** | **21.9** | **-4.1** | **0.10** | **14.0** | **12.9** | **-8.0** | **0.22** |
| **Days to maturity (d)** | | | | | | | | | | | | |
| 1999 SC | . | . | . | . | 94.0 | 94.3 | 0.3 | 0.67 | 95.0 | 96.0 | 1.1 | 0.14 |
| 2000 SC | 98.3 | 98.3 | 0.0 | 1.00 | 101.0 | 100.8 | -0.2 | 0.75 | 93.8 | 93.1 | -0.7 | 0.29 |
| 2001 SC | 100.3 | 99.9 | -0.4 | 0.53 | 113.8 | 114.5 | 0.7 | 0.14 | 95.8 | 94.8 | -1.0 | 0.33 |
| 2000 SV | 110.5 | 108.5 | -1.8 | 0.05 | 107.3 | 107.1 | -0.1 | 0.83 | 97.5 | 97.0 | -0.5 | 0.17 |
| 2001 SV | 99.0 | 104.0 | 5.1 | 0.04 | 109.8 | 111.1 | 1.3 | <0.01 | 89.3 | 91.6 | 2.7 | <0.01 |
| 2002 SV | 139.0 | 137.8 | -0.9 | 0.52 | 119.5 | 118.9 | -0.5 | 0.40 | 94.0 | 95.9 | 2.0 | <0.01 |
| **Mean** | **109.4** | **109.7** | **0.3** | **0.70** | **107.0** | **107.2** | **0.2** | **0.38** | **94.2** | **94.8** | **0.6** | **0.04** |

**Table 6a.** **Comparisons of rhizobium inoculant forms (peat-based powder vs granular) in chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | Powder | Granular | Diff. % | *P* value | Powder | Granular | Diff. % | *P* value | Powder | Granular | Diff. % | *P* value |
| **Plant population (plants $m^{-2}$)** | | | | | | | | | | | | |
| 1999 SC | 39.9 | 44.8 | 12.0 | 0.05 | 28.7 | 37.4 | 30.5 | <0.01 | 67.5 | 61.9 | -8.3 | 0.03 |
| 2000 SC | 41.0 | 44.5 | 8.5 | 0.11 | 33.8 | 36.1 | 6.7 | 0.18 | 108.4 | 101.2 | -6.7 | 0.04 |
| 2001 SC | 40.3 | 40.3 | 0.0 | 1.00 | 35.6 | 36.9 | 3.7 | 0.40 | 96.4 | 96.1 | -0.3 | 0.94 |
| 2000 SV | 38.9 | 39.4 | 1.4 | 0.78 | 37.2 | 34.9 | -6.1 | 0.22 | 89.8 | 87.8 | -2.2 | 0.59 |
| 2001 SV | 36.7 | 38.4 | 4.8 | 0.26 | 33.1 | 34.1 | 3.0 | 0.60 | 114.8 | 114.8 | 0.0 | 0.98 |
| 2002 SV | 34.6 | 35.3 | 1.8 | 0.72 | 38.6 | 37.3 | -3.4 | 0.46 | 84.2 | 88.2 | 4.8 | 0.25 |
| **Mean** | **38.6** | **40.4** | **4.9** | **0.02** | **34.5** | **36.1** | **4.7** | **0.03** | **93.5** | **91.7** | **-2.0** | **0.17** |
| **Seed yield (kg $ha^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 2438 | 2483 | 1.9 | 0.52 | 2024 | 2276 | 12.5 | <0.01 | 1081 | 1121 | 3.6 | 0.38 |
| 2000 SC | 1801 | 1859 | 3.2 | 0.47 | 1916 | 1866 | -2.6 | 0.61 | 1743 | 1608 | -7.8 | 0.16 |
| 2001 SC | 514 | 506 | -1.7 | 0.68 | 628 | 633 | 0.9 | 0.88 | 345 | 386 | 12.0 | 0.19 |
| 2000 SV | 1999 | 2385 | 19.3 | <0.01 | 2449 | 2619 | 6.9 | <0.01 | 1632 | 1878 | 15.0 | <0.01 |
| 2001 SV | 890 | 995 | 11.7 | 0.17 | 941 | 1036 | 10.0 | 0.03 | 476 | 656 | 37.7 | <0.01 |
| 2002 SV | 1982 | 2100 | 6.0 | 0.22 | 2067 | 2398 | 16.0 | <0.01 | 1053 | 1089 | 3.4 | 0.61 |
| **Mean** | **1637** | **1751** | **6.9** | **<0.01** | **1652** | **1772** | **7.3** | **<0.01** | **1035** | **1113** | **7.5** | **<0.01** |
| **Kernel weight (mg $seed^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 180 | 181 | 0.5 | 0.55 | 386 | 384 | -0.4 | 0.80 | 58 | 58 | 0.0 | 0.21 |
| 2000 SC | 173 | 171 | -0.9 | 0.63 | 447 | 446 | -0.3 | 0.82 | 56 | 54 | -3.1 | 0.07 |
| 2001 SC | 204 | 205 | 0.5 | 0.55 | 526 | 526 | 0.0 | 0.89 | 69 | 71 | 3.1 | 0.04 |
| 2000 SV | 188 | 196 | 4.2 | <0.01 | 487 | 493 | 1.1 | 0.13 | 60 | 59 | -1.7 | 0.04 |
| 2001 SV | 201 | 203 | 1.4 | 0.15 | 519 | 523 | 0.8 | 0.21 | 69 | 72 | 4.5 | <0.01 |
| 2002 SV | 183 | 187 | 2.0 | 0.08 | 518 | 529 | 2.1 | 0.19 | 65 | 66 | 2.0 | 0.35 |
| **Mean** | **186** | **189** | **1.4** | **0.02** | **463** | **465** | **0.4** | **0.28** | **61** | **61** | **0.0** | **0.11** |

**Table 6b. Comparisons of rhizobium inoculant forms (peat-based powder vs granular) in chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | Powder | Granular | Diff. % | *P* value | Powder | Granular | Diff. % | *P* value | Powder | Granular | Diff. % | *P* value |
| **Plant height (cm)** | | | | | | | | | | | | |
| 1999 SC | 43.1 | 43.3 | 0.3 | 0.87 | 54.4 | 54.2 | -0.4 | 0.84 | . | . | . | . |
| 2000 SC | 48.5 | 48.4 | -0.1 | 0.96 | 45.8 | 48.1 | 4.9 | 0.09 | 42.1 | 42.5 | 1.0 | 0.68 |
| 2001 SC | 29.3 | 29.7 | 1.3 | 0.52 | 32.6 | 31.9 | -2.1 | 0.39 | 31.3 | 30.8 | -1.4 | 0.42 |
| 2000 SV | 46.9 | 48.6 | 3.7 | 0.09 | 49.7 | 53.1 | 6.8 | <0.01 | 40.8 | 43.4 | 6.3 | 0.04 |
| 2001 SV | 27.9 | 28.3 | 1.6 | 0.35 | 30.2 | 31.3 | 3.7 | 0.06 | 28.8 | 29.3 | 2.0 | 0.32 |
| 2002 SV | 40.3 | 39.2 | -2.6 | 0.26 | 36.0 | 35.9 | -0.2 | 0.93 | 37.1 | 36.4 | -2.0 | 0.12 |
| **Mean** | **39.5** | **39.7** | **0.7** | **0.48** | **42.0** | **42.9** | **2.2** | **0.01** | **36.0** | **36.5** | **1.3** | **0.21** |
| **Lowest pod height (cm)** | | | | | | | | | | | | |
| 1999 SC | 20.1 | 19.6 | -2.5 | 0.40 | 32.0 | 32.7 | 2.2 | 0.34 | | | | |
| 2000 SC | 17.5 | 17.4 | -0.7 | 0.82 | 25.5 | 25.9 | 1.7 | 0.48 | | | | |
| 2001 SC | 16.9 | 17.6 | 3.7 | 0.40 | 15.8 | 16.6 | 5.1 | 0.48 | ----------not measured---------- | | | |
| 2000 SV | 17.9 | 19.1 | 6.6 | 0.03 | 25.9 | 27.1 | 4.8 | 0.14 | | | | |
| 2001 SV | 14.1 | 14.9 | 5.8 | 0.30 | 15.3 | 15.1 | -1.6 | 0.78 | | | | |
| 2002 SV | 13.9 | 13.2 | -5.4 | 0.09 | 18.1 | 17.6 | -2.8 | 0.30 | 13.9 | 12.9 | -7.6 | 0.06 |
| **Mean** | **16.9** | **17.1** | **1.1** | **0.41** | **22.5** | **22.9** | **1.9** | **0.20** | **13.9** | **12.9** | **-7.6** | **0.04** |
| **Days to maturity (d)** | | | | | | | | | | | | |
| 1999 SC | . | . | . | . | 94.7 | 94.0 | -0.7 | 0.09 | 95.5 | 95.7 | 0.3 | 0.52 |
| 2000 SC | 99.0 | 98.7 | -0.3 | 0.67 | 100.4 | 100.3 | -0.1 | 0.89 | 93.3 | 93.3 | 0.0 | 0.85 |
| 2001 SC | 99.9 | 99.8 | -0.1 | 0.85 | 114.2 | 114.0 | -0.2 | 0.52 | 95.9 | 96.1 | 0.2 | 0.75 |
| 2000 SV | 108.8 | 106.4 | -2.1 | <0.01 | 107.3 | 106.8 | -0.4 | 0.21 | 96.7 | 96.6 | -0.1 | 0.55 |
| 2001 SV | 101.0 | 102.3 | 1.3 | 0.34 | 111.1 | 111.2 | 0.1 | 0.83 | 90.6 | 92.1 | 1.6 | <0.01 |
| 2002 SV | 137.1 | 137.1 | 0.0 | 1.00 | 119.1 | 118.6 | -0.5 | 0.20 | 95.8 | 95.7 | -0.1 | 0.55 |
| **Mean** | **109.2** | **108.9** | **-0.3** | **0.50** | **107.3** | **106.9** | **-0.3** | **0.04** | **94.7** | **94.9** | **0.3** | **0.08** |

**Table 7a. Granular inoculant placement (seed-row vs side-banded) in chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | Side-band | Seed-row | Diff. % | *P* value | Side-band | Seed-row | Diff. % | *P* value | Side-band | Seed-row | Diff. % | *P* value |
| **Plant population (plants $m^{-2}$)** | | | | | | | | | | | | |
| 1999 SC | 45.4 | 45.1 | -0.6 | 0.94 | 46.6 | 42.1 | -9.7 | 0 15 | 65.3 | 60.1 | -7.9 | 0.16 |
| 2000 SC | 41.1 | 44.4 | 7.9 | 0.29 | 34.0 | 35.3 | 3.7 | 0.59 | 103.1 | 98.4 | -4.6 | 0.33 |
| 2001 SC | 41.6 | 40.6 | -2.4 | 0.70 | 37.1 | 34.6 | -6.7 | 0.26 | 99.0 | 95.8 | -3.3 | 0.57 |
| 2000 SV | 44.3 | 38.8 | -12.4 | 0.06 | 35.3 | 34.1 | -3.2 | 0.66 | 90.5 | 86.4 | -4.6 | 0.44 |
| 2001 SV | 34.3 | 38.5 | 12.4 | 0.05 | 35.0 | 34.9 | -0.4 | 0.96 | 117.6 | 113.5 | -3.5 | 0.26 |
| 2002 SV | 33.1 | 35.8 | 7.9 | 0.29 | 38.3 | 37.8 | -1.3 | 0.84 | 94.3 | 86.0 | -8.8 | 0.09 |
| **Mean** | **40.0** | **40.5** | **1.4** | **0.62** | **37.7** | **36.5** | **-3.3** | **0.24** | **95.0** | **90.0** | **-5.2** | **0.01** |
| **Seed yield (kg $ha^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 2620 | 2576 | -1.7 | 0.66 | 2331 | 2300 | -1.3 | 0.74 | 1129 | 1116 | -1.1 | 0.84 |
| 2000 SC | 1832 | 1941 | 5.9 | 0.30 | 1910 | 1884 | -1.4 | 0.84 | 1759 | 1531 | -13.0 | 0.07 |
| 2001 SC | 499 | 470 | -5.9 | 0.32 | 608 | 648 | 6.5 | 0.44 | 342 | 404 | 18.1 | 0.17 |
| 2000 SV | 2296 | 2371 | 3.3 | 0.56 | 2578 | 2642 | 2.5 | 0.38 | 1976 | 1990 | 0.7 | 0.90 |
| 2001 SV | 798 | 950 | 19.0 | 0.16 | 1013 | 1059 | 4.5 | 0.43 | 539 | 689 | 27.8 | <0.01 |
| 2002 SV | 2134 | 2136 | 0.1 | 0.99 | 2520 | 2413 | -4.3 | 0.50 | 1142 | 1114 | -2.4 | 0.78 |
| **Mean** | **1734** | **1774** | **2.3** | **0.32** | **1788** | **1794** | **0.3** | **0.95** | **1147** | **1132** | **-1.3** | **0.80** |
| **Kernel weight (mg $seed^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 182 | 181 | -0.2 | 0.85 | 383 | 376 | -1.9 | 0.43 | 59 | 58 | -1.5 | 0.29 |
| 2000 SC | 176 | 169 | -3.9 | 0.14 | 447 | 449 | 0.4 | 0.79 | 54 | 54 | 0.0 | 0.50 |
| 2001 SC | 205 | 206 | 0.6 | 0.59 | 521 | 523 | 0.3 | 0.74 | 70 | 71 | 2.2 | 0.26 |
| 2000 SV | 188 | 194 | 3.0 | 0.15 | 492 | 491 | -0.2 | 0.84 | 59 | 59 | 0.0 | 0.68 |
| 2001 SV | 200 | 205 | 2.5 | 0.09 | 517 | 525 | 1.5 | 0.11 | 72 | 71 | -0.9 | 0.36 |
| 2002 SV | 188 | 191 | 1.2 | 0.43 | 533 | 536 | 0.5 | 0.83 | 65 | 65 | 0.0 | 0.86 |
| **Mean** | **187** | **188** | **0.5** | **0.43** | **464** | **464** | **0.0** | **0.80** | **61** | **61** | **0.0** | **0.82** |

**Table 7b. Granular inoculant placement (seed-row vs side-banded) in chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | Side-band | Seed-row | Diff. % | *P* value | Side-band | Seed-row | Diff. % | *P* value | Side-band | Seed-row | Diff. % | *P* value |
| **Plant height (cm)** | | | | | | | | | | | | |
| 1999 SC | 43.8 | 44.4 | 1.4 | 0.64 | 55.2 | 54.2 | -1.8 | 0.46 | . | . | . | . |
| 2000 SC | 50.1 | 48.8 | -2.7 | 0.46 | 48.6 | 50.4 | 3.6 | 0.35 | 44.5 | 42.3 | -5.1 | 0.13 |
| 2001 SC | 29.0 | 30.0 | 3.4 | 0.23 | 32.3 | 33.5 | 3.9 | 0.27 | 30.9 | 30.9 | 0.0 | 1.00 |
| 2000 SV | 48.8 | 48.8 | 0.0 | 1.00 | 53.4 | 52.4 | -1.9 | 0.47 | 43.3 | 44.8 | 3.5 | 0.39 |
| 2001 SV | 27.1 | 28.8 | 6.0 | 0.02 | 31.3 | 32.1 | 2.8 | 0.30 | 29.5 | 29.1 | -1.3 | 0.64 |
| 2002 SV | 40.1 | 39.8 | -0.9 | 0.78 | 36.0 | 35.6 | -1.0 | 0.70 | 36.8 | 36.5 | -0.7 | 0.71 |
| **Mean** | **40.0** | **40.2** | **0.7** | **0.64** | **43.3** | **43.5** | **0.5** | **0.64** | **37.0** | **36.7** | **-0.7** | **0.60** |
| **Lowest pod height (cm)** | | | | | | | | | | | | |
| 1999 SC | 20.5 | 20.1 | -2.0 | 0.63 | 33.4 | 33.1 | -0.9 | 0.77 | | | | |
| 2000 SC | 18.4 | 18.0 | -2.0 | 0.63 | 25.5 | 27.9 | 9.3 | <0.01 | | | | |
| 2001 SC | 17.0 | 18.3 | 7.4 | 0.23 | 15.3 | 17.8 | 16.4 | 0.13 | ----------not measured---------- | | | |
| 2000 SV | 19.8 | 18.9 | -4.4 | 0.24 | 27.1 | 27.1 | 0.0 | 1.00 | | | | |
| 2001 SV | 14.1 | 14.8 | 4.4 | 0.57 | 14.3 | 16.5 | 15.8 | 0.08 | | | | |
| 2002 SV | 13.8 | 12.9 | -6.4 | 0.15 | 18.4 | 18.3 | -0.7 | 0.86 | 14.4 | 13.1 | -8.7 | 0.11 |
| **Mean** | **17.4** | **17.3** | **-0.7** | **0.76** | **22.8** | **23.8** | **4.7** | **0.01** | **14.4** | **13.1** | **-8.7** | **0.10** |
| **Days to maturity (d)** | | | | | | | | | | | | |
| 1999 SC | . | . | . | . | 94.2 | 93.8 | -0.4 | 0.49 | 95.4 | 95.9 | 0.5 | 0.36 |
| 2000 SC | 98.8 | 98.6 | -0.1 | 0.90 | 100.0 | 100.4 | 0.4 | 0.57 | 93.1 | 93.4 | 0.3 | 0.60 |
| 2001 SC | 100.0 | 99.6 | -0.4 | 0.44 | 114.3 | 113.6 | -0.5 | 0.13 | 95.5 | 96.4 | 0.9 | 0.30 |
| 2000 SV | 106.9 | 106.5 | -0.4 | 0.65 | 106.5 | 106.6 | 0.1 | 0.80 | 96.8 | 96.8 | 0.0 | 1.00 |
| 2001 SV | 100.8 | 100.8 | 0.0 | 1.00 | 111.0 | 110.9 | -0.1 | 0.76 | 91.6 | 91.9 | 0.3 | 0.44 |
| 2002 SV | 136.5 | 138.0 | 1.1 | 0.35 | 118.8 | 118.1 | -0.5 | 0.31 | 96.1 | 95.8 | -0.4 | 0.20 |
| **Mean** | **108.6** | **108.7** | **0.1** | **0.83** | **106.9** | **106.7** | **-0.2** | **0.34** | **94.8** | **95.0** | **0.3** | **0.23** |

**Table 8a. Impact of Starter nitrogen (0 vs 15 kg N ha$^{-1}$) on growth and yields of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | N=0 | N=15 | Diff. % | *P* value | N=0 | N=15 | Diff. % | *P* value | N=0 | N=15 | Diff. % | *P* value |
| **Plant population (plants m$^{-2}$)** | | | | | | | | | | | | |
| 1999 SC | 41.7 | 45.8 | 9.9 | 0.10 | 37.9 | 37.0 | -2.5 | 0.66 | 64.4 | 67.1 | 4.2 | 0.29 |
| 2000 SC | 43.1 | 43.0 | -0.1 | 0.98 | 34.5 | 34.2 | -0.9 | 0.85 | 104.0 | 100.1 | -3.8 | 0.26 |
| 2001 SC | 39.7 | 40.9 | 3.0 | 0.53 | 35.8 | 35.9 | 0.5 | 0.90 | 99.1 | 96.5 | -2.6 | 0.53 |
| 2000 SV | 42.8 | 40.5 | -5.4 | 0.25 | 34.7 | 34.7 | 0.0 | 1.00 | 93.0 | 86.6 | -6.9 | 0.09 |
| 2001 SV | 36.8 | 35.4 | -3.9 | 0.35 | 35.6 | 33.4 | -6.2 | 0.26 | 115.6 | 112.4 | -2.7 | 0.23 |
| 2002 SV | 35.3 | 34.6 | -2.1 | 0.67 | 38.6 | 35.9 | -7.1 | 0.13 | 87.4 | 85.6 | -2.0 | 0.61 |
| **Mean** | **39.9** | **40.0** | **0.3** | **0.88** | **36.2** | **35.2** | **-2.8** | **0.18** | **93.9** | **91.4** | **-2.7** | **0.07** |
| **Seed yield (kg ha$^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 2489 | 2604 | 4.6 | 0.11 | 2127 | 2214 | 4.1 | 0.20 | 1158 | 1106 | -4.5 | 0.25 |
| 2000 SC | 1878 | 1819 | -3.2 | 0.42 | 1918 | 1900 | -0.9 | 0.85 | 1676 | 1677 | 0.1 | 0.89 |
| 2001 SC | 485 | 517 | 6.8 | 0.12 | 593 | 674 | 13.6 | 0.03 | 391 | 368 | -5.8 | 0.47 |
| 2000 SV | 2270 | 2299 | 1.3 | 0.75 | 2554 | 2603 | 1.9 | 0.35 | 1855 | 1915 | 3.2 | 0.48 |
| 2001 SV | 871 | 892 | 2.5 | 0.77 | 940 | 1072 | 14.0 | <0.01 | 563 | 633 | 12.4 | <0.01 |
| 2002 SV | 2058 | 2132 | 3.6 | 0.44 | 2284 | 2476 | 8.4 | 0.10 | 1000 | 1243 | 24.3 | <0.01 |
| **Mean** | **1708** | **1746** | **2.3** | **0.26** | **1705** | **1783** | **4.6** | **<0.01** | **1103** | **1150** | **4.2** | **0.06** |
| **Kernel weight (mg seed$^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 180 | 182 | 1.1 | 0.19 | 375 | 384 | 2.6 | 0.15 | 59 | 58 | -0.6 | 0.56 |
| 2000 SC | 177 | 166 | -6.2 | <0.01 | 452 | 442 | -2.4 | 0.03 | 55 | 54 | -1.8 | 0.26 |
| 2001 SC | 204 | 205 | 0.4 | 0.65 | 526 | 523 | -0.6 | 0.39 | 69 | 70 | 2.3 | 0.11 |
| 2000 SV | 194 | 186 | -4.2 | <0.01 | 493 | 490 | -0.7 | 0.31 | 59 | 59 | 0.0 | 0.78 |
| 2001 SV | 202 | 202 | 0.2 | 0.80 | 520 | 518 | -0.3 | 0.66 | 71 | 71 | 0.0 | 0.37 |
| 2002 SV | 187 | 191 | 2.0 | 0.08 | 525 | 537 | 2.5 | 0.13 | 63 | 68 | 7.6 | <0.01 |
| **Mean** | **188** | **186** | **-1.3** | **0.05** | **463** | **463** | **0.0** | **0.83** | **61** | **61** | **0.0** | **0.03** |

**Table 8b. Impact of Starter nitrogen (0 vs 15 kg N ha$^{-1}$) on harvestability of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | N=0 | N=15 | Diff. % | *P* value | N=0 | N=15 | Diff. % | *P* value | N=0 | N=15 | Diff. % | *P* value |
| **Plant height (cm)** | | | | | | | | | | | | |
| 1999 SC | 43.4 | 43.9 | 1.2 | 0.58 | 55.2 | 55.0 | -0.4 | 0.84 | . | . | . | . |
| 2000 SC | 49.6 | 48.9 | -1.5 | 0.57 | 49.5 | 49.1 | -0.9 | 0.74 | 42.5 | 43.6 | 2.5 | 0.31 |
| 2001 SC | 29.0 | 30.3 | 4.3 | 0.04 | 32.5 | 32.8 | 0.8 | 0.75 | 31.1 | 31.1 | 0.0 | 1.00 |
| 2000 SV | 48.1 | 50.2 | 4.3 | 0.04 | 51.4 | 52.4 | 2.1 | 0.28 | 41.8 | 44.1 | 5.5 | 0.07 |
| 2001 SV | 27.1 | 28.6 | 5.3 | <0.01 | 30.6 | 32.0 | 4.5 | 0.02 | 29.2 | 29.4 | 0.6 | 0.74 |
| 2002 SV | 40.1 | 39.3 | -1.9 | 0.42 | 35.9 | 35.8 | -0.2 | 0.93 | 37.1 | 36.9 | -0.7 | 0.60 |
| **Mean** | **39.7** | **40.3** | **1.6** | **0.10** | **43.0** | **43.3** | **0.7** | **0.38** | **36.4** | **37.0** | **1.8** | **0.08** |
| **Lowest pod height (cm)** | | | | | | | | | | | | |
| 1999 SC | 19.7 | 20.3 | 2.8 | 0.36 | 33.3 | 32.4 | -2.6 | 0.24 | | | | |
| 2000 SC | 17.7 | 18.3 | 3.2 | 0.31 | 26.6 | 26.1 | -1.9 | 0.42 | | | | |
| 2001 SC | 17.4 | 17.4 | 0.0 | 1.00 | 16.2 | 17.5 | 8.1 | 0.26 | ----------not measured---------- | | | |
| 2000 SV | 18.7 | 19.6 | 4.7 | 0.10 | 26.6 | 27.6 | 4.0 | 0.20 | | | | |
| 2001 SV | 14.5 | 14.1 | -3.0 | 0.57 | 15.1 | 16.1 | 6.6 | 0.26 | | | | |
| 2002 SV | 13.9 | 13.4 | -3.6 | 0.25 | 17.6 | 18.6 | 5.3 | 0.06 | 13.2 | 14.3 | 8.5 | 0.04 |
| **Mean** | **17.1** | **17.3** | **1.1** | **0.49** | **23.0** | **23.4** | **1.9** | **0.12** | **13.2** | **14.3** | **8.5** | **0.04** |
| **Days to maturity (d)** | | | | | | | | | | | | |
| 1999 SC | . | . | . | . | 94.3 | 93.8 | -0.6 | 0.18 | 95.4 | 95.6 | 0.3 | 0.52 |
| 2000 SC | 99.8 | 97.4 | -2.4 | <0.01 | 100.6 | 99.6 | -0.9 | 0.04 | 93.5 | 92.9 | -0.6 | 0.10 |
| 2001 SC | 100.1 | 99.9 | -0.2 | 0.46 | 114.0 | 113.9 | -0.1 | 0.83 | 96.6 | 95.7 | -0.9 | 0.14 |
| 2000 SV | 107.4 | 106.2 | -1.1 | 0.04 | 107.1 | 106.1 | -0.9 | <0.01 | 96.9 | 96.4 | -0.5 | 0.02 |
| 2001 SV | 101.4 | 100.1 | -1.3 | 0.34 | 111.6 | 110.4 | -1.0 | <0.01 | 91.8 | 91.1 | -0.7 | <0.01 |
| 2002 SV | 135.6 | 138.1 | 1.9 | 0.03 | 118.8 | 118.0 | -0.6 | 0.09 | 96.0 | 95.6 | -0.5 | 0.04 |
| **Mean** | **108.9** | **108.3** | **-0.5** | **0.21** | **107.2** | **106.5** | **-0.7** | **<0.01** | **95.0** | **94.6** | **-0.5** | **<0.01** |

**Table 9a.** **Impact of Starter phosphorous (0 vs 15 kg $P_2O_5$ $ha^{-1}$) on growth and yields of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | P=0 | P=15 | Diff. % | *P* value | P=0 | P=15 | Diff. % | *P* value | P=0 | P=15 | Diff. % | *P* value |
| **Plant population (plants $m^{-2}$)** | | | | | | | | | | | | |
| 1999 SC | 42.8 | 40.5 | -5.4 | 0.41 | 30.9 | 34.8 | 12.4 | 0.13 | 65.5 | 64.6 | -1.4 | 0.75 |
| 2000 SC | 42.8 | 44.3 | 3.5 | 0.55 | 36.8 | 34.8 | -5.4 | 0.3 | 105.2 | 105.7 | 0.5 | 0.90 |
| 2001 SC | 38.8 | 38.8 | 0.0 | 0.97 | 38.7 | 35.5 | -8.2 | 0.08 | 96.8 | 98.9 | 2.2 | 0.64 |
| 2000 SV | 38.4 | 41.6 | 8.2 | 0.17 | 37.5 | 34.6 | -7.8 | 0.17 | 88.7 | 93.7 | 5.6 | 0.25 |
| 2001 SV | 38.5 | 37.0 | -3.9 | 0.40 | 33.8 | 35.9 | 6.4 | 0.33 | 115.6 | 113.2 | -2.1 | 0.41 |
| 2002 SV | 34.6 | 35.5 | 2.7 | 0.65 | 38.1 | 38.3 | 0.7 | 0.90 | 87.5 | 87.1 | -0.5 | 0.92 |
| **Mean** | **39.3** | **39.6** | **0.7** | **0.76** | **35.9** | **35.6** | **-0.8** | **0.72** | **93.2** | **93.8** | **0.7** | **0.68** |
| **Seed yield (kg $ha^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 2394 | 2434 | 1.7 | 0.63 | 2171 | 2058 | -5.2 | 0.15 | 1096 | 1180 | 7.7 | 0.11 |
| 2000 SC | 1747 | 1866 | 6.8 | 0.20 | 1917 | 1903 | -0.7 | 0.95 | 1746 | 1656 | -5.1 | 0.50 |
| 2001 SC | 539 | 492 | -8.6 | 0.06 | 593 | 607 | 2.3 | 0.74 | 344 | 394 | 14.7 | 0.17 |
| 2000 SV | 2193 | 2228 | 1.6 | 0.74 | 2507 | 2555 | 1.9 | 0.43 | 1643 | 1813 | 10.4 | 0.09 |
| 2001 SV | 1007 | 914 | -9.2 | 0.29 | 990 | 954 | -3.7 | 0.44 | 562 | 595 | 5.9 | 0.20 |
| 2002 SV | 2035 | 2037 | 0.1 | 0.98 | 2267 | 2279 | 0.5 | 0.93 | 1060 | 1012 | -4.5 | 0.56 |
| **Mean** | **1681** | **1693** | **0.7** | **0.81** | **1708** | **1692** | **-0.9** | **0.67** | **1058** | **1104** | **4.4** | **0.21** |
| **Kernel weight (mg $seed^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 182 | 180 | -1.0 | 0.32 | 391 | 375 | -4.1 | 0.04 | 58 | 59 | 2.7 | 0.03 |
| 2000 SC | 170 | 173 | 1.6 | 0.46 | 448 | 451 | 0.6 | 0.65 | 54 | 55 | 2.4 | 0.21 |
| 2001 SC | 204 | 203 | -0.6 | 0.54 | 526 | 528 | 0.3 | 0.70 | 71 | 69 | -3.0 | 0.07 |
| 2000 SV | 193 | 194 | 0.3 | 0.83 | 488 | 492 | 0.9 | 0.28 | 60 | 59 | -1.2 | 0.21 |
| 2001 SV | 202 | 202 | 0.2 | 0.88 | 522 | 521 | -0.2 | 0.80 | 71 | 71 | 0.0 | 0.55 |
| 2002 SV | 182 | 187 | 2.9 | 0.03 | 518 | 522 | 0.8 | 0.67 | 66 | 64 | -3.9 | 0.12 |
| **Mean** | **187** | **188** | **0.3** | **0.38** | **465** | **462** | **-0.5** | **0.80** | **61** | **61** | **0.0** | **0.22** |

**Table 9b. Impact of Starter phosphorous (0 vs 15 kg $P_2O_5$ $ha^{-1}$) on harvestability of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | P=0 | P=15 | Diff. % | *P* value | P=0 | P=15 | Diff. % | *P* value | P=0 | P=15 | Diff. % | *P* value |
| **Plant height (cm)** | | | | | | | | | | | | |
| 1999 SC | 41.8 | 43.5 | 4.1 | 0.10 | 54.4 | 55.2 | 1.5 | 0.47 | . | . | . | . |
| 2000 SC | 47.7 | 48.5 | 1.7 | 0.58 | 45.5 | 49.4 | 8.6 | 0.01 | 42.0 | 42.0 | 0.0 | 1.00 |
| 2001 SC | 29.3 | 29.2 | -0.3 | 0.90 | 31.2 | 32.5 | 4.3 | 0.15 | 30.5 | 31.0 | 1.6 | 0.42 |
| 2000 SV | 47.0 | 48.3 | 2.7 | 0.30 | 52.7 | 50.7 | -3.8 | 0.08 | 40.9 | 41.3 | 1.0 | 0.77 |
| 2001 SV | 28.1 | 27.5 | -2.1 | 0.28 | 30.4 | 30.5 | 0.3 | 0.90 | 29.3 | 29.2 | -0.6 | 0.80 |
| 2002 SV | 39.8 | 40.0 | 0.6 | 0.82 | 36.1 | 35.9 | -0.5 | 0.83 | 36.5 | 37.2 | 1.8 | 0.23 |
| **Mean** | **39.0** | **39.7** | **1.6** | **0.19** | **42.2** | **42.9** | **1.6** | **0.13** | **35.9** | **36.1** | **0.8** | **0.51** |
| **Lowest pod height (cm)** | | | | | | | | | | | | |
| 1999 SC | 19.3 | 19.5 | 0.7 | 0.85 | 32.3 | 32.9 | 2.1 | 0.43 | | | | |
| 2000 SC | 16.8 | 17.2 | 2.0 | 0.60 | 24.3 | 27.0 | 11.3 | <0.01 | | | | |
| 2001 SC | 16.5 | 17.6 | 6.6 | 0.21 | 15.0 | 16.8 | 11.7 | 0.19 | ----------not measured---------- | | | |
| 2000 SV | 18.4 | 18.8 | 2.3 | 0.49 | 27.1 | 27.2 | 0.3 | 0.93 | | | | |
| 2001 SV | 15.1 | 14.6 | -3.3 | 0.58 | 13.7 | 15.6 | 14.0 | 0.07 | | | | |
| 2002 SV | 13.7 | 14.1 | 3.0 | 0.40 | 17.7 | 17.1 | -3.3 | 0.30 | 12.9 | 12.8 | -0.6 | 0.90 |
| **Mean** | **16.7** | **17.1** | **1.8** | **0.28** | **22.1** | **23.2** | **4.9** | **<0.01** | **12.9** | **12.8** | **-0.6** | **0.89** |
| **Days to maturity (d)** | | | | | | | | | | | | |
| 1999 SC | . | . | . | . | 94.5 | 94.2 | -0.3 | 0.57 | 95.7 | 95.5 | -0.3 | 0.55 |
| 2000 SC | 98.7 | 99.5 | 0.8 | 0.32 | 100.8 | 100.5 | -0.2 | 0.64 | 93.3 | 93.5 | 0.3 | 0.53 |
| 2001 SC | 99.9 | 100.2 | 0.3 | 0.53 | 114.4 | 114.0 | -0.4 | 0.22 | 95.3 | 96.5 | 1.2 | 0.09 |
| 2000 SV | 107.8 | 107.5 | -0.2 | 0.71 | 107.2 | 107.0 | -0.2 | 0.68 | 96.8 | 96.8 | 0.0 | 0.73 |
| 2001 SV | 103.2 | 101.6 | -1.5 | 0.32 | 111.3 | 111.4 | 0.2 | 0.62 | 91.7 | 91.7 | 0.0 | 1.00 |
| 2002 SV | 136.8 | 135.5 | -0.9 | 0.34 | 118.9 | 118.7 | -0.2 | 0.62 | 95.8 | 95.8 | 0.0 | 1.00 |
| **Mean** | **109.3** | **108.9** | **-0.4** | **0.4** | **107.3** | **107.1** | **-0.2** | **0.27** | **94.8** | **95.0** | **0.2** | **0.23** |

**Table 10a. Effect of JumpStart on growth and yields of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year-site | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No JumpStart | With JumpStart | Diff. % | *P* value | No JumpStart | With JumpStart | Diff. % | *P* value | No JumpStart | With JumpStart | Diff. % | *P* value |
| **Plant population (plants $m^{-2}$)** | | | | | | | | | | | | |
| 1999 SC | 43.7 | 43.9 | 0.3 | 0.95 | 37.2 | 29.3 | -21.3 | <0.01 | 62.6 | 75.0 | 19.7 | <0.01 |
| 2000 SC | 43.6 | 43.6 | 0.0 | 1.00 | 35.2 | 34.7 | -1.3 | 0.76 | 102.2 | 103.3 | 1.1 | 0.71 |
| 2001 SC | 40.5 | 38.7 | -4.3 | 0.30 | 36.0 | 36.6 | 1.7 | 0.66 | 95.6 | 98.2 | 2.7 | 0.47 |
| 2000 SV | 38.4 | 40.3 | 5.0 | 0.29 | 36.7 | 34.9 | -4.8 | 0.28 | 88.0 | 90.3 | 2.6 | 0.49 |
| 2001 SV | 38.2 | 36.5 | -4.3 | 0.23 | 34.5 | 33.8 | -2.0 | 0.68 | 116.5 | 113.9 | -2.2 | 0.26 |
| 2002 SV | 34.9 | 36.6 | 4.7 | 0.29 | 38.5 | 38.3 | -0.5 | 0.90 | 84.2 | 86.1 | 2.3 | 0.53 |
| **Mean** | **39.9** | **39.9** | **0.0** | **0.94** | **36.3** | **34.6** | **-4.8** | **<0.01** | **91.5** | **94.4** | **3.2** | **0.02** |
| **Seed yield (kg $ha^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 2209 | 2450 | 10.9 | <0.01 | 2162 | 2082 | -3.7 | 0.18 | 1068 | 1137 | 6.5 | 0.09 |
| 2000 SC | 1809 | 1766 | -2.4 | 0.52 | 1875 | 1922 | 2.5 | 0.43 | 1669 | 1632 | -2.2 | 0.65 |
| 2001 SC | 523 | 501 | -4.1 | 0.25 | 595 | 623 | 4.6 | 0.4 | 349 | 345 | -1.4 | 0.86 |
| 2000 SV | 2156 | 2214 | 2.7 | 0.49 | 2559 | 2513 | -1.8 | 0.34 | 1689 | 1792 | 6.1 | 0.18 |
| 2001 SV | 920 | 917 | -0.4 | 0.96 | 964 | 930 | -3.5 | 0.36 | 536 | 523 | -2.6 | 0.48 |
| 2002 SV | 1972 | 1964 | -0.4 | 0.93 | 2207 | 2127 | -3.6 | 0.43 | 1010 | 1025 | 1.4 | 0.82 |
| **Mean** | **1621** | **1668** | **2.9** | **0.19** | **1701** | **1677** | **-1.4** | **0.34** | **1039** | **1069** | **2.9** | **0.33** |
| **Kernel weight (mg $seed^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 177 | 180 | 1.9 | 0.01 | 384 | 382 | -0.7 | 0.66 | 58 | 58 | 0.0 | 0.55 |
| 2000 SC | 169 | 167 | -0.9 | 0.58 | 450 | 443 | -1.5 | 0.14 | 55 | 55 | 0.0 | 0.99 |
| 2001 SC | 204 | 205 | 0.3 | 0.64 | 521 | 526 | 0.8 | 0.20 | 70 | 70 | 0.0 | 0.29 |
| 2000 SV | 191 | 193 | 0.7 | 0.56 | 488 | 493 | 1.1 | 0.08 | 60 | 59 | -1.5 | 0.04 |
| 2001 SV | 200 | 201 | 0.7 | 0.46 | 518 | 514 | -0.9 | 0.14 | 70 | 70 | 0.0 | 0.18 |
| 2002 SV | 184 | 184 | 0.0 | 0.69 | 520 | 520 | 0.0 | 0.96 | 64 | 65 | 2.3 | 0.25 |
| **Mean** | **185** | **186** | **0.7** | **0.29** | **463** | **462** | **-0.2** | **0.75** | **61** | **61** | **0.0** | **0.74** |

**Table 10b. Effect of JumpStart on harvestability of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year-site | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No JumpStart | With JumpStart | Diff. % | *P* value | No JumpStart | With JumpStart | Diff. % | *P* value | No JumpStart | With JumpStart | Diff. % | *P* value |
| **Plant height (cm)** | | | | | | | | | | | | |
| 1999 SC | 41.8 | 42.6 | 1.9 | 0.32 | 54.2 | 54.8 | 1.0 | 0.52 | . | . | . | . |
| 2000 SC | 47.6 | 48.7 | 2.3 | 0.35 | 47.9 | 47.4 | -0.9 | 0.70 | 41.5 | 42.2 | 1.7 | 0.46 |
| 2001 SC | 29.7 | 29.3 | -1.3 | 0.44 | 32.4 | 31.7 | -2.2 | 0.33 | 30.7 | 31.2 | 1.5 | 0.35 |
| 2000 SV | 46.7 | 48.6 | 4.0 | 0.04 | 51.8 | 51.0 | -1.6 | 0.33 | 41.9 | 43.0 | 2.6 | 0.32 |
| 2001 SV | 28.1 | 28.2 | 0.2 | 0.90 | 31.2 | 30.9 | -1.0 | 0.57 | 29.2 | 29.2 | 0.0 | 0.92 |
| 2002 SV | 39.9 | 38.5 | -3.4 | 0.11 | 35.4 | 35.7 | 0.7 | 0.68 | 36.7 | 37.4 | 1.8 | 0.14 |
| **Mean** | **39.1** | **39.4** | **0.9** | **0.31** | **42.6** | **42.4** | **-0.5** | **0.46** | **36.0** | **36.6** | **1.6** | **0.08** |
| **Lowest pod height (cm)** | | | | | | | | | | | | |
| 1999 SC | 19.0 | 19.4 | 2.3 | 0.41 | 33.0 | 32.2 | -2.2 | 0.27 | | | | |
| 2000 SC | 17.5 | 17.4 | -0.9 | 0.76 | 26.0 | 25.9 | -0.2 | 0.93 | | | | |
| 2001 SC | 17.0 | 16.9 | -0.3 | 0.94 | 16.3 | 16.0 | -2.1 | 0.73 | ----------not measured---------- | | | |
| 2000 SV | 18.4 | 18.7 | 1.6 | 0.52 | 26.6 | 27.3 | 2.6 | 0.35 | | | | |
| 2001 SV | 15.0 | 14.9 | -0.7 | 0.89 | 15.0 | 15.4 | 2.7 | 0.61 | | | | |
| 2002 SV | 13.4 | 13.8 | 3.0 | 0.30 | 17.7 | 17.1 | -3.1 | 0.21 | 13.2 | 13.6 | 2.7 | 0.48 |
| **Mean** | **16.8** | **16.9** | **0.9** | **0.53** | **22.8** | **22.7** | **-0.5** | **0.74** | **13.2** | **13.6** | **2.7** | **0.46** |
| **Days to maturity (d)** | | | | | | | | | | | | |
| 1999 SC | . | . | . | . | 94.0 | 94.4 | 0.4 | 0.33 | 95.8 | 95.8 | 0.0 | 0.82 |
| 2000 SC | 98.4 | 99.0 | 0.6 | 0.36 | 100.7 | 100.2 | -0.4 | 0.28 | 93.4 | 93.4 | 0.0 | 0.87 |
| 2001 SC | 99.9 | 100.3 | 0.5 | 0.14 | 114.0 | 114.2 | 0.1 | 0.56 | 95.6 | 96.1 | 0.5 | 0.35 |
| 2000 SV | 108.1 | 107.2 | -0.9 | 0.07 | 107.0 | 107.2 | 0.2 | 0.52 | 97.0 | 96.8 | -0.3 | 0.19 |
| 2001 SV | 101.7 | 101.8 | 0.1 | 0.97 | 110.8 | 111.1 | 0.3 | 0.18 | 91.3 | 91.1 | -0.2 | 0.47 |
| 2002 SV | 138.1 | 136.4 | -1.3 | 0.09 | 118.7 | 119.3 | 0.5 | 0.12 | 95.5 | 95.5 | 0.0 | 0.79 |
| **Mean** | **109.2** | **108.9** | **-0.3** | **0.38** | **107.0** | **107.2** | **0.2** | **0.15** | **94.8** | **94.8** | **0.0** | **0.72** |

**Table 11a. Effect of JumpStart with Starter nitrogen (0 vs 15 kg N ha$^{-1}$) on growth and yields of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year-site | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JumpStart & 0 N | JumpStart & 15 N | Diff. % | *P* value | JumpStart & 0 N | JumpStart & 15 N | Diff. % | *P* value | JumpStart & 0 N | JumpStart & 15 N | Diff. % | *P* value |
| **Plant population (plants m$^{-2}$)** | | | | | | | | | | | | |
| 1999 SC | 39.0 | 49.5 | 26.9 | 0.04 | 29.8 | 30.5 | 2.5 | 0.86 | 70.8 | 81.5 | 15.2 | 0.04 |
| 2000 SC | 47.5 | 43.3 | -8.9 | 0.33 | 34.5 | 34.3 | -0.7 | 0.94 | 96.3 | 101.0 | 4.9 | 0.49 |
| 2001 SC | 34.0 | 37.8 | 11.0 | 0.32 | 36.8 | 36.8 | 0.0 | 1.00 | 100.5 | 97.0 | -3.5 | 0.67 |
| 2000 SV | 43.0 | 41.8 | -2.9 | 0.75 | 33.8 | 34.3 | 1.5 | 0.89 | 96.0 | 87.8 | -8.6 | 0.27 |
| 2001 SV | 37.8 | 36.0 | -4.6 | 0.57 | 36.5 | 33.0 | -9.6 | 0.37 | 107.3 | 110.0 | 2.6 | 0.59 |
| 2002 SV | 36.8 | 36.5 | -0.7 | 0.94 | 38.0 | 36.0 | -5.3 | 0.58 | 81.3 | 79.5 | -2.2 | 0.80 |
| **Mean** | **39.7** | **40.8** | **2.8** | **0.48** | **34.9** | **34.1** | **-2.2** | **0.62** | **92.0** | **92.8** | **0.9** | **0.77** |
| **Seed yield (kg ha$^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 2379 | 2599 | 9.2 | 0.13 | 2021 | 2015 | -0.3 | 0.96 | 1253 | 1058 | -15.6 | 0.03 |
| 2000 SC | 1672 | 1908 | 14.1 | 0.11 | 1998 | 1857 | -7.1 | 0.44 | 1714 | 1669 | -2.6 | 0.79 |
| 2001 SC | 498 | 548 | 10.1 | 0.23 | 547 | 639 | 16.8 | 0.21 | 395 | 386 | -2.3 | 0.89 |
| 2000 SV | 2317 | 2435 | 5.1 | 0.53 | 2603 | 2598 | -0.2 | 0.97 | 1860 | 1954 | 5.0 | 0.58 |
| 2001 SV | 945 | 892 | -5.6 | 0.73 | 915 | 1081 | 18.1 | 0.04 | 667 | 673 | 0.9 | 0.89 |
| 2002 SV | 1963 | 2272 | 15.8 | 0.11 | 2384 | 2481 | 4.1 | 0.66 | 1016 | 1278 | 25.8 | 0.07 |
| **Mean** | **1659** | **1808** | **9.0** | **0.02** | **1701** | **1728** | **1.6** | **0.55** | **1155** | **1165** | **0.9** | **0.71** |
| **Kernel weight (mg seed$^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 180 | 184 | 2.0 | 0.23 | 370 | 385 | 4.1 | 0.26 | 59 | 58 | -2.4 | 0.24 |
| 2000 SC | 166 | 161 | -3.4 | 0.38 | 450 | 436 | -3.2 | 0.15 | 56 | 53 | -5.8 | 0.04 |
| 2001 SC | 203 | 206 | 1.5 | 0.37 | 525 | 525 | 0.0 | 1.00 | 68 | 70 | 2.9 | 0.29 |
| 2000 SV | 193 | 190 | -1.2 | 0.68 | 494 | 493 | -0.2 | 0.91 | 58 | 58 | 0.0 | 0.40 |
| 2001 SV | 201 | 207 | 3.2 | 0.11 | 520 | 515 | -1.0 | 0.47 | 73 | 72 | -1.0 | 0.44 |
| 2002 SV | 191 | 191 | 0.0 | 0.90 | 529 | 541 | 2.3 | 0.46 | 65 | 69 | 5.6 | 0.20 |
| **Mean** | **187** | **187** | **0.0** | **0.70** | **462** | **463** | **0.3** | **0.83** | **61** | **61** | **0.0** | **0.88** |

**Table 11b. Effect of JumpStart with Starter nitrogen (0 vs 15 kg N ha$^{-1}$) on harvestability of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year-site | JumpStart & 0 N | JumpStart & 15 N | Diff. % | *P* value | JumpStart & 0 N | JumpStart & 15 N | Diff. % | *P* value | JumpStart & 0 N | JumpStart & 15 N | Diff. % | *P* value |
| **Plant height (cm)** | | | | | | | | | | | | |
| 1999 SC | 41.4 | 43.6 | 5.3 | 0.22 | 55.6 | 55.8 | 0.4 | 0.92 | . | . | . | . |
| 2000 SC | 47.0 | 51.3 | 9.0 | 0.11 | 51.3 | 51.3 | 0.0 | 1.00 | 42.3 | 43.5 | 3.0 | 0.55 |
| 2001 SC | 29.3 | 30.5 | 4.3 | 0.28 | 31.8 | 32.8 | 3.1 | 0.53 | 30.3 | 32.3 | 6.6 | 0.07 |
| 2000 SV | 49.3 | 51.3 | 4.1 | 0.33 | 50.8 | 53.3 | 4.9 | 0.20 | 40.0 | 47.5 | 18.8 | <0.01 |
| 2001 SV | 27.5 | 28.5 | 3.6 | 0.29 | 30.8 | 32.3 | 4.9 | 0.21 | 29.8 | 30.8 | 3.4 | 0.38 |
| 2002 SV | 39.0 | 38.8 | -0.6 | 0.89 | 36.5 | 34.5 | -5.5 | 0.15 | 37.8 | 37.8 | 0.0 | 1.00 |
| **Mean** | **39.0** | **40.8** | **4.5** | **0.02** | **43.3** | **43.8** | **1.2** | **0.48** | **36.0** | **38.4** | **6.5** | **<0.01** |
| **Lowest pod height (cm)** | | | | | | | | | | | | |
| 1999 SC | 17.4 | 20.6 | 18.4 | <0.01 | 32.8 | 32.6 | -0.6 | 0.89 | | | | |
| 2000 SC | 17.3 | 18.3 | 5.8 | 0.37 | 26.8 | 25.5 | -4.7 | 0.31 | | | | |
| 2001 SC | 17.0 | 16.3 | -4.4 | 0.61 | 17.5 | 17.0 | -2.9 | 0.83 | ----------not measured---------- | | | |
| 2000 SV | 19.3 | 19.0 | -1.3 | 0.81 | 28.5 | 28.0 | -1.8 | 0.76 | | | | |
| 2001 SV | 15.0 | 14.8 | -1.7 | 0.87 | 15.8 | 16.0 | 1.6 | 0.89 | | | | |
| 2002 SV | 14.3 | 13.3 | -7.0 | 0.25 | 17.3 | 17.8 | 2.9 | 0.61 | 12.8 | 14.0 | 9.8 | 0.26 |
| **Mean** | **16.7** | **17.2** | **2.6** | **0.52** | **23.5** | **23.2** | **-1.2** | **0.66** | **12.8** | **14.0** | **9.8** | **0.24** |
| **Days to maturity (d)** | | | | | | | | | | | | |
| 1999 SC | . | . | . | . | 94.4 | 93.4 | -1.1 | 0.23 | 95.6 | 96.0 | 0.4 | 0.60 |
| 2000 SC | 98.0 | 98.5 | 0.5 | 0.73 | 100.8 | 99.3 | -1.5 | 0.11 | 93.3 | 93.3 | 0.0 | 1.00 |
| 2001 SC | 100.8 | 100.5 | -0.2 | 0.71 | 114.0 | 114.0 | 0.0 | 1.00 | 96.0 | 96.3 | 0.3 | 0.83 |
| 2000 SV | 106.3 | 104.8 | -1.4 | 0.20 | 106.8 | 106.0 | -0.7 | 0.28 | 96.8 | 96.8 | 0.0 | 1.00 |
| 2001 SV | 102.0 | 100.0 | -2.0 | 0.47 | 111.8 | 110.5 | -1.1 | 0.04 | 92.0 | 91.5 | -0.5 | 0.28 |
| 2002 SV | 134.0 | 137.0 | 2.2 | 0.19 | 118.5 | 117.3 | -1.1 | 0.15 | 95.8 | 95.8 | 0.0 | 1.00 |
| **Mean** | **108.2** | **108.2** | **0.0** | **0.95** | **107.2** | **106.2** | **-0.9** | **<0.01** | **94.9** | **95.0** | **0.1** | **0.93** |

**Table 12a. Effect of JumpStart with Starter phosphorous (0 vs 15 kg $P_2O_5$ $ha^{-1}$) on growth and yields of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year-site | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JumpStart & 0 P | JumpStart & 15 P | Diff. % | *P* value | JumpStart & 0 P | JumpStart & 15 P | Diff. % | *P* value | JumpStart & 0 P | JumpStart & 15 P | Diff. % | *P* value |
| **Plant population (plants $m^{-2}$)** | | | | | | | | | | | | |
| 1999 SC | 50.3 | 39.0 | -22.4 | 0.03 | 27.8 | 29.8 | 7.2 | 0.64 | 74.0 | 70.8 | -4.4 | 0.52 |
| 2000 SC | 43.8 | 47.5 | 8.6 | 0.39 | 37.0 | 34.5 | -6.8 | 0.45 | 100.0 | 96.3 | -3.8 | 0.59 |
| 2001 SC | 44.0 | 34.0 | -22.7 | 0.01 | 40.3 | 36.8 | -8.7 | 0.26 | 96.5 | 100.5 | 4.1 | 0.62 |
| 2000 SV | 40.3 | 43.0 | 6.8 | 0.49 | 33.8 | 33.8 | 0.0 | 1.00 | 86.3 | 96.0 | 11.3 | 0.20 |
| 2001 SV | 36.8 | 37.8 | 2.7 | 0.74 | 35.3 | 36.5 | 3.5 | 0.75 | 118.8 | 107.3 | -9.7 | 0.03 |
| 2002 SV | 37.0 | 36.8 | -0.7 | 0.94 | 37.0 | 38.0 | 2.7 | 0.78 | 99.5 | 81.3 | -18.3 | 0.01 |
| **Mean** | **42.0** | **39.7** | **-5.6** | **0.15** | **35.2** | **34.9** | **-0.8** | **0.84** | **95.8** | **92.0** | **-4.0** | **0.16** |
| **Seed yield (kg $ha^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 2456 | 2379 | -3.2 | 0.59 | 2300 | 2021 | -12.1 | 0.04 | 1195 | 1253 | 4.9 | 0.52 |
| 2000 SC | 1742 | 1672 | -4.0 | 0.63 | 2020 | 1998 | -1.1 | 0.84 | 1682 | 1714 | 1.9 | 0.73 |
| 2001 SC | 500 | 498 | -0.5 | 0.95 | 655 | 547 | -16.4 | 0.14 | 339 | 395 | 16.5 | 0.37 |
| 2000 SV | 2393 | 2317 | -3.2 | 0.68 | 2539 | 2603 | 2.5 | 0.54 | 1824 | 1860 | 2.0 | 0.83 |
| 2001 SV | 967 | 945 | -2.3 | 0.88 | 1023 | 915 | -10.6 | 0.19 | 592 | 667 | 12.7 | 0.09 |
| 2002 SV | 2045 | 1963 | -4.0 | 0.66 | 2389 | 2384 | -0.2 | 0.98 | 1047 | 1016 | -3.0 | 0.83 |
| **Mean** | **1715** | **1659** | **-3.3** | **0.38** | **1782** | **1701** | **-4.5** | **0.16** | **1093** | **1155** | **5.7** | **0.37** |
| **Kernel weight (mg $seed^{-1}$)** | | | | | | | | | | | | |
| 1999 SC | 181 | 180 | -0.3 | 0.84 | 389 | 370 | -4.9 | 0.15 | 58 | 59 | 1.7 | 0.40 |
| 2000 SC | 170 | 166 | -2.0 | 0.61 | 444 | 450 | 1.5 | 0.49 | 53 | 56 | 6.6 | 0.07 |
| 2001 SC | 206 | 203 | -1.7 | 0.30 | 532 | 525 | -1.3 | 0.36 | 70 | 68 | -2.5 | 0.35 |
| 2000 SV | 196 | 193 | -1.7 | 0.55 | 497 | 494 | -0.6 | 0.66 | 59 | 58 | -1.6 | 0.31 |
| 2001 SV | 203 | 201 | -1.0 | 0.61 | 521 | 520 | -0.2 | 0.88 | 73 | 73 | 0.0 | 0.79 |
| 2002 SV | 183 | 191 | 4.4 | 0.06 | 525 | 529 | 0.8 | 0.80 | 66 | 65 | -2.0 | 0.63 |
| **Mean** | **188** | **187** | **-0.6** | **0.70** | **466** | **462** | **-1.0** | **0.54** | **61** | **61** | **0.0** | **0.88** |

**Table 12b. Effect of JumpStart with Starter phosphorous (0 vs 15 kg $P_2O_5$ $ha^{-1}$) on harvestability of chickpea and lentil grown at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year-site | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JumpStart & 0 P | JumpStart & 15 P | Diff. % | *P* value | JumpStart & 0 P | JumpStart & 15 P | Diff. % | *P* value | JumpStart & 0 P | JumpStart & 15 P | Diff. % | *P* value |
| **Plant height (cm)** | | | | | | | | | | | | |
| 1999 SC | 42.8 | 41.4 | -3.3 | 0.44 | 54.8 | 55.6 | 1.5 | 0.68 | . | . | . | . |
| 2000 SC | 49.5 | 47.0 | -5.1 | 0.34 | 45.3 | 51.3 | 13.3 | 0.03 | 42.0 | 42.3 | 0.6 | 0.91 |
| 2001 SC | 28.5 | 29.3 | 2.6 | 0.52 | 30.3 | 31.8 | 5.0 | 0.35 | 30.5 | 30.3 | -0.8 | 0.82 |
| 2000 SV | 49.8 | 49.3 | -1.0 | 0.81 | 53.5 | 50.8 | -5.1 | 0.16 | 41.5 | 40.0 | -3.6 | 0.54 |
| 2001 SV | 27.8 | 27.5 | -0.9 | 0.79 | 31.0 | 30.8 | -0.8 | 0.83 | 28.8 | 29.8 | 3.5 | 0.38 |
| 2002 SV | 37.0 | 39.0 | 5.4 | 0.29 | 36.0 | 36.5 | 1.4 | 0.71 | 36.5 | 37.8 | 3.4 | 0.20 |
| **Mean** | **39.4** | **39.0** | **-0.9** | **0.67** | **42.3** | **43.3** | **2.3** | **0.20** | **35.9** | **36.0** | **0.4** | **0.84** |
| **Lowest pod height (cm)** | | | | | | | | | | | | |
| 1999 SC | 19.6 | 17.4 | -11.2 | 0.07 | 32.0 | 32.8 | 2.5 | 0.58 | | | | |
| 2000 SC | 16.3 | 17.3 | 6.2 | 0.37 | 25.0 | 26.8 | 7.0 | 0.16 | | | | |
| 2001 SC | 17.0 | 17.0 | 0.0 | 1.00 | 15.8 | 17.5 | 11.1 | 0.45 | ----------not measured---------- | | | |
| 2000 SV | 18.8 | 19.3 | 2.7 | 0.63 | 27.8 | 28.5 | 2.7 | 0.65 | | | | |
| 2001 SV | 14.8 | 15.0 | 1.7 | 0.87 | 14.8 | 15.8 | 6.8 | 0.57 | | | | |
| 2002 SV | 13.5 | 14.3 | 5.6 | 0.38 | 17.5 | 17.3 | -1.4 | 0.80 | 13.0 | 12.8 | -1.9 | 0.82 |
| **Mean** | **16.8** | **16.7** | **-0.2** | **0.92** | **22.5** | **23.5** | **4.3** | **0.13** | **13.0** | **12.8** | **-1.9** | **0.81** |
| **Days to maturity (d)** | | | | | | | | | | | | |
| 1999 SC | . | . | . | . | 94.8 | 94.4 | -0.4 | 0.63 | 95.2 | 95.6 | 0.4 | 0.60 |
| 2000 SC | 99.5 | 98.0 | -1.5 | 0.30 | 100.8 | 100.8 | 0.0 | 1.00 | 93.5 | 93.3 | -0.3 | 0.71 |
| 2001 SC | 100.0 | 100.8 | 0.8 | 0.27 | 114.3 | 114.0 | -0.2 | 0.67 | 96.5 | 96.0 | -0.5 | 0.67 |
| 2000 SV | 106.3 | 106.3 | 0.0 | 1.00 | 107.3 | 106.8 | -0.5 | 0.47 | 96.3 | 96.8 | 0.5 | 0.24 |
| 2001 SV | 101.5 | 102.0 | 0.5 | 0.86 | 111.5 | 111.8 | 0.2 | 0.67 | 91.8 | 92.0 | 0.3 | 0.59 |
| 2002 SV | 134.8 | 134.0 | -0.6 | 0.74 | 119.0 | 118.5 | -0.4 | 0.56 | 95.8 | 95.8 | 0.0 | 1.00 |
| **Mean** | **108.4** | **108.2** | **-0.2** | **0.81** | **107.4** | **107.2** | **-0.2** | **0.45** | **94.8** | **94.9** | **0.1** | **0.82** |

**Table 13a. Effect of TagTeam on growth and yields of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year-site | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No rhizobial inoculant | With TagTeam | Diff. % | *P* value | No rhizobial inoculant | With TagTeam | Diff. % | *P* value | No rhizobial inoculant | With TagTeam | Diff. % | *P* value |
| **Plant population (plants $m^{-2}$)** | | | | | | | | | | | | |
| 2000 SC | 44.5 | 48.5 | 9.0 | 0.36 | 32.0 | 35.0 | 9.4 | 0.37 | 98.5 | 100.5 | 2.0 | 0.77 |
| 2001 SC | 48.5 | 39.5 | -18.6 | 0.02 | 34.8 | 35.0 | 0.7 | 0.94 | 92.5 | 100.8 | 8.9 | 0.31 |
| 2002 SC | 44.0 | 49.0 | 11.4 | 0.25 | 40.1 | 38.7 | -3.7 | 0.72 | . | . | . | . |
| 2000 SV | 39.3 | 39.0 | -0.6 | 0.95 | 36.3 | 33.5 | -7.6 | 0.45 | 87.3 | 82.5 | -5.4 | 0.53 |
| 2001 SV | 35.0 | 36.8 | 5.0 | 0.57 | 36.8 | 34.5 | -6.1 | 0.56 | 127.3 | 110.8 | -13.0 | <0.01 |
| 2002 SV | 36.3 | 39.5 | 9.0 | 0.35 | 39.8 | 40.5 | 1.9 | 0.83 | 85.8 | 89.5 | 4.4 | 0.59 |
| **Mean** | **41.3** | **42.0** | **1.9** | **0.61** | **36.6** | **36.2** | **-1.1** | **0.76** | **98.3** | **96.8** | **-1.5** | **0.64** |
| **Seed yield (kg $ha^{-1}$)** | | | | | | | | | | | | |
| 2000 SC | 1646 | 1790 | 8.7 | 0.33 | 1857 | 1698 | -9 | 0.45 | 1745 | 1736 | -0.5 | 0.91 |
| 2001 SC | 557 | 536 | -3.8 | 0.62 | 554 | 586 | 5.8 | 0.66 | 248 | 374 | 51.1 | 0.04 |
| 2002 SC | 2220 | 2532 | 14.1 | 0.38 | 1345 | 1412 | 5.0 | <0.01 | . | . | . | . |
| 2000 SV | 1851 | 2309 | 24.7 | 0.02 | 2526 | 2657 | 5.2 | 0.21 | 1359 | 1645 | 21.1 | 0.09 |
| 2001 SV | 648 | 805 | 24.3 | 0.30 | 752 | 1037 | 38 | <0.01 | 210 | 625 | 197.4 | <0.01 |
| 2002 SV | 1526 | 2239 | 46.7 | <0.01 | 1798 | 2253 | 25 | 0.06 | 691 | 903 | 30.7 | 0.14 |
| **Mean** | **1408** | **1702** | **20.9** | **<0.01** | **1423** | **1548** | **8.8** | **0.02** | **803** | **1056** | **31.5** | **<0.01** |
| **Kernel weight (mg $seed^{-1}$)** | | | | | | | | | | | | |
| 2000 SC | 166 | 169 | 1.6 | 0.68 | 452 | 449 | -1 | 0.80 | 57 | 54 | -6.3 | 0.04 |
| 2001 SC | 203 | 202 | -0.7 | 0.65 | 515 | 519 | 0.8 | 0.60 | 68 | 70 | 2.2 | 0.42 |
| 2002 SC | 168 | 172 | 2.1 | 0.04 | 440 | 451 | 2.5 | <0.01 | . | . | . | . |
| 2000 SV | 185 | 195 | 5.1 | 0.08 | 489 | 496 | 1.4 | 0.32 | 62 | 60 | -3.6 | 0.02 |
| 2001 SV | 186 | 201 | 8.4 | <0.01 | 495 | 520 | 4.9 | <0.01 | 66 | 72 | 9.9 | <0.01 |
| 2002 SV | 175 | 187 | 7.2 | <0.01 | 500 | 529 | 5.7 | 0.09 | 57 | 64 | 13.4 | 0.01 |
| **Mean** | **180** | **187** | **3.9** | **0.01** | **479** | **488** | **2.0** | **0.01** | **61** | **62** | **0.4** | **0.01** |

**Table 13b. Effect of TagTeam on harvestability of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year-site | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No rhizobial inoculant | With TagTeam | Diff. % | *P* value | No rhizobial inoculant | With TagTeam | Diff. % | *P* value | No rhizobial inoculant | With TagTeam | Diff. % | *P* value |
| **Plant height (cm)** | | | | | | | | | | | | |
| 2000 SC | 46.8 | 49.8 | 6.4 | 0.25 | 47.3 | 50.5 | 6.9 | 0.22 | 38.8 | 42.5 | 9.7 | 0.08 |
| 2001 SC | 29.3 | 30.0 | 2.6 | 0.52 | 31.8 | 32.3 | 1.6 | 0.75 | 30.8 | 30.3 | -1.6 | 0.64 |
| 2002 SC | 47.0 | 44.3 | -5.9 | 0.01 | 40.0 | 41.8 | 4.4 | 0.87 | . | . | . | . |
| 2000 SV | 44.8 | 48.5 | 8.4 | 0.07 | 49.8 | 54.5 | 9.5 | 0.02 | 38.5 | 43.3 | 12.3 | 0.06 |
| 2001 SV | 26.5 | 27.5 | 3.8 | 0.29 | 31.3 | 30.0 | -4.0 | 0.29 | 28.3 | 30.0 | 6.2 | 0.13 |
| 2002 SV | 37.5 | 39.3 | 4.7 | 0.35 | 33.5 | 35.5 | 6.0 | 0.15 | 37.5 | 37.3 | -0.7 | 0.80 |
| **Mean** | **38.6** | **39.9** | **3.2** | **0.10** | **38.9** | **40.8** | **4.7** | **0.01** | **34.8** | **36.7** | **5.5** | **0.01** |
| **Lowest pod height (cm)** | | | | | | | | | | | | |
| 2000 SC | 17.3 | 18.5 | 7.2 | 0.26 | 26.3 | 26.8 | 1.9 | 0.68 | | | | |
| 2001 SC | 15.8 | 17.5 | 11.1 | 0.24 | 16.8 | 16.8 | 0.0 | 1.00 | | | | |
| 2002 SC | 16.5 | 16.3 | -1.5 | 1.00 | 18.3 | 20.0 | 9.6 | 0.74 | ----------not measured---------- | | | |
| 2000 SV | 17.5 | 20.3 | 15.7 | 0.01 | 25.3 | 27.5 | 8.9 | 0.18 | | | | |
| 2001 SV | 15.0 | 15.0 | 0.0 | 1.00 | 15.8 | 16.5 | 4.8 | 0.67 | | | | |
| 2002 SV | 13.5 | 14.3 | 5.6 | 0.38 | 16.3 | 18.3 | 12.3 | 0.04 | 14.0 | 13.5 | -3.6 | 0.65 |
| **Mean** | **15.9** | **17.0** | **6.5** | **0.04** | **19.8** | **21.0** | **6.1** | **0.07** | **14.0** | **13.5** | **-3.6** | **0.65** |
| **Days to maturity (d)** | | | | | | | | | | | | |
| 2000 SC | 98.3 | 98 | -0.3 | 0.86 | 101.0 | 100.3 | -0.7 | 0.42 | 93.8 | 92.5 | -1.3 | 0.07 |
| 2001 SC | 100.3 | 100.5 | 0.2 | 0.71 | 113.8 | 114.3 | 0.4 | 0.39 | 95.8 | 95.3 | -0.5 | 0.67 |
| 2002 SC | 151.0 | 152.3 | 0.8 | 0.34 | 140.5 | 139.8 | -0.5 | 0.03 | . | . | . | . |
| 2000 SV | 110.5 | 107.5 | -2.7 | 0.01 | 107.3 | 106.5 | -0.7 | 0.28 | 97.5 | 97.3 | -0.3 | 0.55 |
| 2001 SV | 99.0 | 101.0 | 2.0 | 0.47 | 109.8 | 110.8 | 0.9 | 0.09 | 89.3 | 92.3 | 3.4 | <0.01 |
| 2002 SV | 139.0 | 136.3 | -2.0 | 0.22 | 119.5 | 119.3 | -0.2 | 0.77 | 94.0 | 96.5 | 2.7 | <0.01 |
| **Mean** | **116.3** | **115.9** | **-0.4** | **0.57** | **115.3** | **115.1** | **-0.1** | **0.62** | **94.1** | **94.8** | **0.7** | **0.02** |

**Table 14a. Comparisons between TagTeam and other rhizobial inoculants (peat-based powder and granular) in affecting growth and yields of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year-site | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Other inoculants | With TagTeam | Diff. % | *P* value | Other inoculants | With TagTeam | Diff. % | *P* value | Other inoculants | With TagTeam | Diff. % | *P* value |
| **Plant population (plants $m^{-2}$)** | | | | | | | | | | | | |
| 2000 SC | 42.3 | 48.5 | 14.8 | 0.10 | 36.6 | 35.0 | -4.4 | 0.57 | 107.8 | 100.5 | -6.7 | 0.23 |
| 2001 SC | 36.3 | 39.5 | 9.0 | 0.32 | 37.9 | 35.0 | -7.6 | 0.29 | 96.9 | 100.8 | 4.0 | 0.58 |
| 2002 SC | 48.3 | 49.0 | 1.6 | 0.46 | 40.0 | 38.7 | -3.4 | 0.92 | . | . | . | . |
| 2000 SV | 37.5 | 39.0 | 4.0 | 0.66 | 39.4 | 33.5 | -14.9 | 0.06 | 89.9 | 82.5 | -8.2 | 0.26 |
| 2001 SV | 39.4 | 36.8 | -6.7 | 0.33 | 33.0 | 34.5 | 4.5 | 0.65 | 114.0 | 110.8 | -2.9 | 0.46 |
| 2002 SV | 33.4 | 39.5 | 18.4 | 0.04 | 38.6 | 40.5 | 4.9 | 0.55 | 81.5 | 89.5 | 9.8 | 0.18 |
| **Mean** | **39.5** | **42.0** | **6.4** | **0.06** | **37.6** | **36.2** | **-3.7** | **0.25** | **98.0** | **96.8** | **-1.2** | **0.65** |
| **Seed yield (kg $ha^{-1}$)** | | | | | | | | | | | | |
| 2000 SC | 1750 | 1790 | 2.3 | 0.81 | 1873 | 1698 | -9.3 | 0.36 | 1773 | 1736 | -2.1 | 0.81 |
| 2001 SC | 558 | 536 | -3.9 | 0.54 | 562 | 586 | 4.2 | 0.71 | 346 | 374 | 8.2 | 0.60 |
| 2002 SC | 2721 | 2532 | -6.9 | 0.30 | 1670 | 1412 | -15.4 | 0.52 | . | . | . | . |
| 2000 SV | 2093 | 2309 | 10.3 | 0.18 | 2492 | 2657 | 6.7 | 0.07 | 1553 | 1645 | 5.9 | 0.53 |
| 2001 SV | 1027 | 805 | -21.6 | 0.09 | 974 | 1037 | 6.5 | 0.38 | 547 | 625 | 14.1 | 0.04 |
| 2002 SV | 2030 | 2239 | 10.3 | 0.21 | 2206 | 2253 | 2.1 | 0.81 | 1066 | 903 | -15.3 | 0.19 |
| **Mean** | **1695** | **1702** | **0.4** | **0.94** | **1570** | **1548** | **-1.4** | **0.71** | **1039** | **1056** | **1.7** | **0.99** |
| **Kernel weight (mg $seed^{-1}$)** | | | | | | | | | | | | |
| 2000 SC | 170 | 169 | -0.6 | 0.86 | 450 | 449 | -0.3 | 0.88 | 54 | 54 | 0.0 | 0.50 |
| 2001 SC | 204 | 202 | -1.0 | 0.49 | 523 | 519 | -0.7 | 0.57 | 71 | 70 | -1.9 | 0.40 |
| 2002 SC | 179 | 172 | -4.3 | 0.48 | 474 | 451 | -5.0 | 0.14 | . | . | . | . |
| 2000 SV | 192 | 195 | 1.5 | 0.54 | 484 | 496 | 2.5 | 0.04 | 60 | 60 | -0.9 | 0.52 |
| 2001 SV | 202 | 201 | -0.2 | 0.88 | 523 | 520 | -0.7 | 0.55 | 71 | 72 | 1.8 | 0.15 |
| 2002 SV | 182 | 187 | 3.0 | 0.13 | 515 | 529 | 2.6 | 0.34 | 66 | 64 | -2.7 | 0.47 |
| **Mean** | **187** | **187** | **0.0** | **0.83** | **488** | **488** | **0.0** | **0.76** | **63** | **62** | **-1.5** | **0.30** |

**Table 14b. Comparisons between TagTeam and other rhizobial inoculants (peat-based powder and granular) in affecting harvestability of chickpea and lentil at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year-site | Desi Chickpea | | | | Kabuli Chickpea | | | | Lentil | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Other inoculants | With TagTeam | Diff. % | *P* value | Other inoculants | With TagTeam | Diff. % | *P* value | Other inoculants | With TagTeam | Diff. % | *P* value |
| **Plant height (cm)** | | | | | | | | | | | | |
| 2000 SC | 46.8 | 49.8 | 6.4 | 0.19 | 45.6 | 50.5 | 10.7 | 0.04 | 42.0 | 42.5 | 1.2 | 0.78 |
| 2001 SC | 29.6 | 30.0 | 1.3 | 0.71 | 31.6 | 32.3 | 2.0 | 0.65 | 30.5 | 30.3 | -0.8 | 0.79 |
| 2002 SC | 42.1 | 44.3 | 5.0 | 0.84 | 42.1 | 41.8 | -0.9 | 0.19 | . | . | . | . |
| 2000 SV | 45.6 | 48.5 | 6.3 | 0.11 | 52.3 | 54.5 | 4.3 | 0.19 | 40.6 | 43.3 | 6.5 | 0.22 |
| 2001 SV | 28.3 | 27.5 | -2.7 | 0.36 | 30.1 | 30.0 | -0.4 | 0.90 | 29.6 | 30.0 | 1.3 | 0.70 |
| 2002 SV | 41.1 | 39.3 | -4.6 | 0.25 | 36.1 | 35.5 | -1.7 | 0.60 | 36.5 | 37.3 | 2.1 | 0.37 |
| **Mean** | **38.9** | **39.9** | **2.5** | **0.14** | **39.6** | **40.8** | **2.8** | **0.08** | **35.9** | **36.7** | **2.2** | **0.21** |
| **Lowest pod height (cm)** | | | | | | | | | | | | |
| 2000 SC | 17.1 | 18.5 | 8.0 | 0.16 | 23.9 | 26.8 | 12.0 | <0.01 | | | | |
| 2001 SC | 16.3 | 17.5 | 7.7 | 0.33 | 14.6 | 16.8 | 14.5 | 0.29 | | | | |
| 2002 SC | 15.9 | 16.3 | 2.4 | 0.53 | 19.1 | 20.0 | 4.6 | 0.11 | ----------not measured---------- | | | |
| 2000 SV | 18.3 | 20.3 | 11.0 | 0.03 | 26.8 | 27.5 | 2.8 | 0.60 | | | | |
| 2001 SV | 15.3 | 15.0 | -1.6 | 0.85 | 13.1 | 16.5 | 25.7 | 0.03 | | | | |
| 2002 SV | 13.8 | 14.3 | 3.6 | 0.50 | 17.8 | 18.3 | 2.8 | 0.55 | 12.9 | 13.5 | 4.9 | 0.51 |
| **Mean** | **16.1** | **17.0** | **5.4** | **0.04** | **19.2** | **21.0** | **9.1** | **<0.01** | **12.9** | **13.5** | **4.9** | **0.51** |
| **Days to maturity (d)** | | | | | | | | | | | | |
| 2000 SC | 98.3 | 98.0 | -0.3 | 0.84 | 100.8 | 100.3 | -0.5 | 0.53 | 93.1 | 92.5 | -0.7 | 0.29 |
| 2001 SC | 99.9 | 100.5 | 0.6 | 0.29 | 114.5 | 114.3 | -0.2 | 0.62 | 94.8 | 95.3 | 0.5 | 0.62 |
| 2002 SC | 150.3 | 152.3 | 1.3 | 0.02 | 137.8 | 139.8 | 1.5 | 0.25 | . | . | . | . |
| 2000 SV | 108.5 | 107.5 | -0.9 | 0.32 | 107.1 | 106.5 | -0.6 | 0.30 | 97.0 | 97.3 | 0.3 | 0.49 |
| 2001 SV | 104.0 | 101.0 | -2.9 | 0.21 | 111.1 | 110.8 | -0.3 | 0.46 | 91.6 | 92.3 | 0.7 | 0.12 |
| 2002 SV | 137.8 | 136.3 | -1.1 | 0.44 | 118.9 | 119.3 | 0.3 | 0.62 | 95.9 | 96.5 | 0.7 | 0.09 |
| **Mean** | **116.4** | **115.9** | **-0.4** | **0.41** | **115.0** | **115.1** | **0.1** | **0.72** | **94.5** | **94.8** | **0.3** | **0.30** |

**Table 15. Response of kabuli chickpea seed size (% ≥9-mm in diameter) to inoculation and fertility management, at Swift Current (SC) and Stewart Valley (SV), Saskatchewan, 1999-2002.**

| Year-site | (1) Rhizobial inoculation | | | (2) Rhizobial inoculant forms | | | (3) Granular inoculant placement | | |
|---|---|---|---|---|---|---|---|---|---|
| | No rhizobia | With rhizobia | *P* value | Peat-based powder | Granular | *P* value | Side-band | Seed-row | *P* value |
| 1999 SC | 59.8 | 56.8 | 0.64 | 56 | 56.1 | 0.97 | 55.8 | 53.6 | 0.67 |
| 2000 SC | 75.2 | 71.8 | 0.31 | 72 | 70.9 | 0.55 | 72 | 70.4 | 0.56 |
| 2001 SC | 85 | 87.2 | 0.17 | 88.1 | 87.3 | 0.39 | 85.6 | 86.4 | 0.51 |
| 2001 SV | 84.9 | 89 | 0.02 | 88.1 | 89.2 | 0.23 | 89.1 | 89.8 | 0.59 |
| 2002 SV | 84.1 | 86.1 | 0.5 | 85.2 | 88.4 | 0.08 | 89.8 | 89.5 | 0.92 |
| **Mean** | **77.8** | **78.2** | **0.8** | **77.9** | **78.4** | **0.57** | **78.5** | **77.9** | **0.69** |

| | (4) Starter-N | | | (5) Starter-P | | | (6) JumpStart | | |
|---|---|---|---|---|---|---|---|---|---|
| | N = 0 | N = 15 | *P* value | P = 0 | P = 15 | *P* value | No JumpStart | JumpStart | *P* value |
| 1999 SC | 54.2 | 57.4 | 0.38 | 57 | 54 | 0.48 | 56.1 | 58.6 | 0.46 |
| 2000 SC | 73.4 | 69.4 | 0.04 | 72.8 | 72.7 | 0.97 | 71.9 | 72.6 | 0.69 |
| 2001 SC | 86.2 | 86.8 | 0.54 | 87.9 | 86.8 | 0.28 | 86.4 | 87.2 | 0.38 |
| 2001 SV | 88.8 | 88.7 | 0.89 | 88.9 | 89 | 0.94 | 88.5 | 87.7 | 0.33 |
| 2002 SV | 86.8 | 90.1 | 0.07 | 86.6 | 86 | 0.74 | 87.1 | 86.6 | 0.77 |
| **Mean** | **77.9** | **78.5** | **0.52** | **78.6** | **77.7** | **0.35** | **78** | **78.5** | **0.52** |

| | (7) JumpStart + Starter-N | | | (8) JumpStart + Starter-P | | | (9) TagTeam | | |
|---|---|---|---|---|---|---|---|---|---|
| | JumpStart & 0 N | JumpStart & 15 N | *P* Value | JumpStart & 0 P | JumpStart & 15 P | *P* Value | No inoculant | With TagTeam | *P* Value |
| 1999 SC† | | | | | | | | | |
| 2000 SC | 75.7 | 68.2 | 0.07 | 74.9 | 75.7 | 0.83 | 75.2 | 70.9 | 0.27 |
| 2001 SC | 84.4 | 86.4 | 0.29 | 89.4 | 84.4 | 0.01 | 85 | 85.1 | 0.96 |
| 2001 SV | 88.8 | 88.2 | 0.73 | 88.7 | 88.8 | 0.95 | 84.9 | 88.1 | 0.1 |
| 2002 SV | 88.6 | 90.5 | 0.59 | 87.6 | 88.6 | 0.78 | 84.1 | 87.8 | 0.29 |
| **Mean** | **78.4** | **79.1** | **0.7** | **79.6** | **78.4** | **0.52** | **79.6** | **80.6** | **0.46** |

†: TagTeam was included in 2002 SC instead of 1999 SC.

**Table 16. Effect of phosphate at the rates of 0,17,and 34 kg $P_2O_5$ $ha^{-1}$) on the seed size fractions (%) of kabuli chickpea grown at the early- and late-seeding dates, in Swift Current, Saskatchewan, 1998-2000.**

| Year | Early May Seeding | | | | Late May Seeding | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 17 | 34 | $P < 0.05$ | 0 | 17 | 34 | $P < 0.05$ |
| | | | | **Seed size >10 mm** | | | | |
| 1998 | 14.9 | 14.1 | 16.0 | 0.53 | 19.5 | 18.8 | 22.3 | 0.18 |
| 1999 | 26.3 | 30.7 | 30.6 | 0.23 | 17.9 | 19.4 | 24.3 | 0.08 |
| 2000 | 22.2 | 22.7 | 22.5 | 0.96 | 28.1 | 21.9 | 23.6 | 0.03 |
| **Mean** | **21.2** | **22.5** | **23.0** | **0.30** | **20.6** | **19.7** | **23.4** | **0.04** |
| | | | | **Seed size betwwen 9-10 mm** | | | | |
| 1998 | 20.1 | 16.1 | 18.3 | 0.08 | 20.9 | 21.8 | 24.2 | 0.18 |
| 1999 | 40.8 | 41.9 | 42.5 | 0.38 | 40.5 | 39.7 | 41.2 | 0.16 |
| 2000 | 44.0 | 43.2 | 41.9 | 0.10 | 41.9 | 47.0 | 44.6 | 0.26 |
| **Mean** | **35.0** | **33.7** | **34.2** | **0.31** | **32.9** | **34.0** | **35.1** | **0.10** |
| | | | | **Seed size between 8-9 mm** | | | | |
| 1998 | 52.0 | 55.3 | 54.4 | 0.19 | 46.7 | 47.2 | 43.7 | 0.28 |
| 1999 | 26.8 | 22.8 | 22.2 | 0.10 | 31.6 | 31.3 | 27.0 | 0.07 |
| 2000 | 27.4 | 28.0 | 29.0 | 0.64 | 24.8 | 25.0 | 25.7 | 0.92 |
| **Mean** | **35.4** | **35.4** | **35.2** | **0.99** | **36.3** | **36.4** | **33.4** | **0.04** |
| | | | | **Seed size < 8 mm** | | | | |
| 1998 | 13.0 | 14.5 | 11.4 | 0.21 | 12.8 | 12.2 | 9.9 | < 0.01 |
| 1999 | 6.2 | 4.7 | 4.7 | 0.8 | 10.0 | 9.6 | 7.5 | 0.03 |
| 2000 | 6.5 | 6.2 | 6.6 | 0.67 | 5.2 | 6.2 | 6.1 | 0.04 |
| **Mean** | **8.5** | **8.5** | **7.6** | **0.27** | **10.2** | **10.0** | **8.2** | **< 0.01** |

**Table 17a**. Effect of Rhizobium inoculation on root nodule number and mass in chickpea at Swift Current (SC) and Stewart Valley (SV), 2001-2002.

| Year-site | Desi | | | Kabuli | | | Lentil | | |
|---|---|---|---|---|---|---|---|---|---|
| | Not Inoculated | Inoculated | Diff. % | Not Inocul. | Inoculated | Diff. % | Not Inocul. | Inoculated | Diff. % |
| **Nodule number per plant** | | | | | | | | | |
| 2001SC | 3.3 | 6.5 | 49.2 | 0.8 | 7.7 | 89.6 | 1.0 | 10.9 | 90.8 |
| 2001SV | 1.6 | 8.6 | 81.4 | 1.0 | 13.5 | 92.6 | 0.4 | 8.3 | 95.2 |
| 2002SV | 2.2 | 17.8 | 87.6 | 7.4 | 26.0 | 71.5 | n.d. | n.d. | n.d. |
| **Nodule mass per ten plants (g dry mass)** | | | | | | | | | |
| 2001SC | 0.038 | 0.095 | 60.0 | 0.132 | 0.297 | 55.6 | 0.028 | 0.103 | 72.8 |
| 2001SV | 0.008 | 0.199 | 95.6 | 0.017 | 0.203 | 91.6 | 0.015 | 0.080 | 81.3 |
| 2002SV | 0.153 | 0.917 | 83.3 | 0.425 | 1.375 | 69.1 | n.d. | n.d. | n.d. |
| | | | | | | | | | |

**Table 17b**. Effect of peat powder or granular inoculant on root nodule number and mass in chickpea at Swift Current (SC) and Stewart Valley (SV), 2001-2002.

| Year-site | Desi | | | Kabuli | | | Lentil | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peat Powder | Granular | Diff. % | Peat Powder | Granular | Diff. % | Peat Powder | Granular | Diff. % |
| **Nodule number per plant** | | | | | | | | | |
| 2001SC | 4.5 | 8.4 | 46.4 | 6.5 | 8.8 | 26.1 | 7.9 | 13.8 | 42.8 |
| 2001SV | 5.7 | 11.5 | 50.4 | 13.8 | 12.9 | -6.9 | 5.1 | 11.4 | 55.3 |
| 2002SV | 12.4 | 23.1 | 46.3 | 22.1 | 29.8 | 25.8 | n.d. | n.d. | n.d. |
| **Nodule mass per ten plants (g dry mass)** | | | | | | | | | |
| 2001SC | 0.040 | 0.151 | 73.5 | 0.240 | 0.355 | 32.4 | 0.069 | 0.137 | 49.6 |
| 2001SV | 0.133 | 0.265 | 49.8 | 0.214 | 0.191 | -12.0 | 0.060 | 0.100 | 40.0 |
| 2002SV | 0.796 | 1.037 | 23.2 | 1.137 | 1.612 | 29.5 | n.d. | n.d. | n.d. |
| | | | | | | | | | |

**Table 17c.** Effect of P fertilizer on root nodule number and mass in chickpea at Swift Current (SC) and Stewart Valley (SV), 2001-2002. All treatments had granular inoculant.

| Year-site | Desi | | | Kabuli | | | Lentil | | |
|---|---|---|---|---|---|---|---|---|---|
| | P=0 | P=15 | Diff. % | P=0 | P=15 | Diff. % | P=0 | P=15 | Diff. % |
| **Nodule number per plant** | | | | | | | | | |
| 2001SC | 8.4 | 5.6 | -50.0 | 8.8 | 8.5 | -3.5 | 13.8 | 12.1 | -14.0 |
| 2001SV | 11.5 | 11.0 | -4.5 | 12.9 | 14.8 | 12.8 | 11.4 | 11.5 | 0.9 |
| 2002SV | 23.1 | 14.3 | -61.5 | 29.8 | 25.3 | -17.8 | n.d. | n.d. | n.d. |
| **Nodule mass per ten plants (g dry mass)** | | | | | | | | | |
| 2001SC | 0.151 | 0.115 | -31.3 | 0.355 | 0.213 | -66.7 | 0.137 | 0.119 | -15.1 |
| 2001SV | 0.265 | 0.193 | -37.3 | 0.191 | 0.215 | 11.2 | 0.100 | 0.091 | -9.9 |
| 2002SV | 1.037 | 1.304 | 20.5 | 1.612 | 1.288 | 25.2 | n.d. | n.d. | n.d. |
| | | | | | | | | | |

**Table 17d.** Effect of N fertilizer on root nodule number and mass in chickpea at Swift Current (SC) and Stewart Valley (SV), 2001-2002. All treatments had granular inoculant.

| Year-site | Desi | | | Kabuli | | | Lentil | | |
|---|---|---|---|---|---|---|---|---|---|
| | P=15 | N=15 P=15 | Diff. % | P=15 | N=15 P=15 | Diff. % | P=15 | N=15 P=15 | Diff. % |
| **Nodule number per plant** | | | | | | | | | |
| 2001SC | 5.6 | 6.2 | 9.7 | 8.5 | 10.6 | 19.8 | [illegible] | 9.7 | -24.7 |
| 2001SV | 11.0 | 8.5 | -29.4 | 14.8 | 7.1 | -108.5 | 11.5 | 6.9 | -66.7 |
| 2002SV | 14.3 | 18.5 | 22.7 | 25.3 | 22.9 | -10.5 | n.d. | n.d. | n.d. |
| **Nodule mass per ten plants (g dry mass)** | | | | | | | | | |
| 2001SC | 0.115 | 0.058 | -98.3 | 0.213 | .208 | -2.4 | 0.119 | 0.042 | -183.3 |
| 2001SV | 0.193 | 0.093 | -107.5 | 0.215 | 0.113 | -99.1 | 0.091 | 0.038 | -139.5 |
| 2002SV | 1.304 | 1.252 | -4.2 | 1.288 | 1.222 | -5.4 | n.d. | n.d. | n.d. |
| | | | | | | | | | |

**Table 17e.** Effect of TagTeam or P fertilizer on root nodule number and mass in chickpea at Swift Current (SC) and Stewart Valley (SV), 2001-2002.

| Year-site | Desi | | | Kabuli | | | Lentil | | |
|---|---|---|---|---|---|---|---|---|---|
| | P=0 | P=15 | Tag Team | P=0 | P=15 | Tag Team | P=0 | P=15 | Tag Team |
| **Nodule number per plant** | | | | | | | | | |
| 2001SC | 8.4 | 5.6 | 6.7 | 8.8 | 8.5 | 8.2 | 13.7 | 12.1 | 12.1 |
| 2001SV | 11.5 | 11.0 | 6.0 | 12.9 | 14.8 | 8.7 | 11.4 | 11.5 | 10.3 |
| 2002SV | 23.1 | 14.3 | 20.8 | 29.8 | 25.3 | 19.5 | n.d. | n.d. | n.d. |
| **Nodule mass per ten plants (g dry mass)** | | | | | | | | | |
| 2001SC | 0.151 | 0.115 | 0.169 | 0.355 | 0.213 | 0.164 | 0.137 | 0.119 | 0.085 |
| 2001SV | 0.265 | 0.193 | 0.079 | 0.191 | 0.215 | 0.128 | 0.100 | 0.091 | 0.092 |
| 2002SV | 1.037 | 1.304 | 0.761 | 1.612 | 1.288 | 1.117 | n.d. | n.d. | n.d. |
| | | | | | | | | | |